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PROGRESS REPORT
of the
WESTERN UTILIZATION RESEARCH AND DEVELOPMENT DIVISION
AGRICULTURAL RESEARCH SERVICE

This progress report includes a summary of the current research of the Division and a preliminary report of progress made during the preceding year. It is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on USDA and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of USDA and cooperative research issued between July 1, 1968 and April 1, 1969. Current agricultural research findings are also published in the monthly USDA publication, Agricultural Research. This progress report was compiled in the Western Utilization Research and Development Division, Agricultural Research Service, U.S. Department of Agriculture, Albany, California.

UNITED STATES DEPARTMENT OF AGRICULTURE

Washington, D. C.

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INTRODUCTION

This report summarizes the current program and progress during FY 1969 on research conducted at the Western Utilization Research and Development Division, Agricultural Research Service.

Research Areas Covered by this Report

The following research problem areas are within the scope of the Western Utilization Research and Development Division: (1) new and improved fruit and vegetable products; (2) new and improved food products from field crops; (3) new and improved feed and industrial products from field crops; (4) new and improved poultry meat and egg products; (5) new and improved products from wool and mohair; (6) expansion of foreign markets for U.S. farm products; (7) protection of food supplies from harmful microorganisms and naturally occurring toxins; (8) alleviating soil, water, and air pollution; and (9) insure food products free from toxic residues from agricultural sources.

The farm commodities dealt with in this report are the cereal grains, wheat, rice, and barley; alfalfa and other forage crops; wool and mohair; citrus, subtropical, deciduous and other fruits; tree nuts; potatoes, dry beans and peas, and other vegetables; castor, safflower and other western oilseeds; and poultry and eggs. (Some phases of research on certain of these commodities are pursued in other Utilization Research Divisions.)

Pharmacological research for four Utilization Research Divisions is conducted at the Albany laboratory of the Western Division, and is described in the report as it applies to various subject areas. (Progress on commodities assigned to other Divisions should be found in their reports.)

Organization of the Division

The Western Utilization Research and Development Division is one of five Utilization Divisions of the Agricultural Research Service. Research and development are carried on for the Western Division by a staff headquartered in the Western Regional Research Laboratory, Albany, California. A smaller Department-owned laboratory is operated in Pasadena, California. Laboratory space and facilities in Puyallup, Washington, are utilized through a cooperative arrangement with Washington State University, Institute of Agricultural Sciences; and laboratory space and facilities in Honolulu, through a cooperative arrangement with the University of Hawaii.

The Albany research staff is organized into six commodity-oriented Laboratories (Cereals, Field Crops, Fruit, Poultry Products, Vegetables, and Wool and Mohair), three functional Laboratories (Pharmacology, Chemical Physics, and Engineering and Development), and a Pioneering Laboratory concerned with basic studies of plant enzymes. The staff at Pasadena is organized as the Subtropical Fruit Laboratory. The Western Regional Research Laboratory at Albany also houses the Division Director's staff, the staff required for Administrative support of the Division, and that responsible for Plant Management--that is, operation of the buildings, facilities, and grounds.

Division scientists and engineers not only conduct or supervise research in their own experimental facilities, but also greatly extend the scope and influence of their work by planning and supervising developmental activities carried on by cooperating private firms, processor organizations, or industry groups, and by arranging for research by well-qualified scientists elsewhere under research contracts and grants. In addition, certain grants of research funds are placed with investigators in foreign countries; the cost of these foreign research efforts on behalf of American agricultural interests is borne by Public Law 480 funds.

Examples of Recent Accomplishments of the Western Utilization Research and Development Division

"Dry" Caustic Peeling of Potatoes. A new peeling process will virtually eliminate the water pollution caused by the commercial peeling of potatoes, which is now equivalent to the domestic sewage from seven million people. A "dry" caustic peeling process for potatoes, developed by Department scientists, has been tested with commercial equipment at semi-plant scale. With this technique, as much as 95% of the peel waste can be removed from the potato without the use of water, thus avoiding 75% of the organic water pollution arising from present peeling methods, as well as keeping nearly all of the lye out of the plant effluent. An added benefit is a marked reduction of peeling losses, giving increased product. The dry peeling waste is expected to find outlets as animal feed. One major potato processor has applied for a FWPCA grant to install a 20,000 lb. per hour or larger plant to evaluate the process on a full-size commercial processing line. Another has purchased the semi-plant-scale line for its own use. This accomplishment will avoid the need for investment of about 11 million dollars in secondary waste treatment facilities and more than 4 million dollars annually in operating costs. This can benefit all users of waterways (municipalities, sportsmen, farmers, industries, etc.) and can reduce prices that the consumer must pay for processed potato products.

Wet Processing of Alfalfa. A practical process for recovery of leaf protein has moved one step closer to realization. A California alfalfa dehydrating company, working with Department scientists, has started a commercial scale operation to reduce the cost of production of dehydrated alfalfa and to

recover high protein concentrate as a co-product. The design of their new plant is based on a pilot plant developed by Department scientists to separate fresh alfalfa into two primary products, a good quality dehydrated alfalfa, and a high-protein concentrate which is also rich in carotene and xanthophyll. The wet processing operation produces about 100 gallons of expressed juice per minute and is run in conjunction with a dehydrator which has a current annual production of 65,000 tons of dehy per year. With the new process added, the dehydrator throughput should be increased by at least 30%. The carotene-xanthophyll fraction is valuable for poultry feeding even without the protein, and an extraction process is being studied to prepare a pigment-free protein preparation suitable for human use. The process provides the basis for direct utilization of vast amounts of leaf protein as human food, and still permits the preparation of valuable animal feeds. Previous efforts to recover food protein directly from leaves have emphasized yield of edible protein, and have viewed feed fractions as byproducts. The recovery of maximum feed values is expected to make the new process economically sound, with a bonus of producing a 50% protein product representing about 15% of original protein of the alfalfa.

Popped Grains for Feed Use. All grains fed in commercial beef feedlots are processed to improve their digestibility. Department scientists have studied hot air expanding or popping grains as an alternative to the more conventional steaming and flaking or pressure-cooking and flaking operations. Milo pops like corn; other grains puff to various degrees. An experimental 1-ton per hour popper was used to prepare grain for a sheep feeding test. Animals appear to prefer the new forms of grain. Test results encouraged a Texas company to build their own grain popper. The commercial machine, processing 4 tons of grain per hour, sells for \$22,000 and, to date, orders for 50 machines have been received. Savings in processing costs of \$1 per ton of grain are claimed. Extending this to the national scene, the 30 million cattle handled annually in U.S. feedlots consume an average of 15 pounds of grain daily for 150 days, so almost 34 million tons of grain must be processed to feed them. If savings of the order claimed by the manufacturers could be realized on even a portion of this grain, it would amount to many million dollars per year.

Improved Frozen Orange Juice Concentrate. The Department has developed and demonstrated a new system of aroma recovery for frozen citrus concentrates. This method, known as WURVAC, has formed the basis for variations now used by several of the largest citrus processors. The "cutback" process, long in use, requires overconcentration of the juice followed by addition of fresh juice to result in the sale-strength of 42% solids. WURVAC collects very strong aroma solution from the vacuum evaporator in the cooled sealant liquid of the vacuum pump. This can be returned to concentrate without appreciable dilution and in quantity sufficient to give an improved product. The WURVAC aroma collected is complete, not merely that of peel oil. This development may also result in more highly concentrated citrus products, both liquid and powders, which have natural aromas. It is based on years of work in the composition of citrus flavors.

Sour Dough French Bread Secrets Discovered. Tantalizing, delectable, highly prized San Francisco sour dough French breads take off daily aboard the nation's airlines destined for fine shops and restaurants throughout the United States. Now, Department scientists have isolated and identified the heretofore elusive yeast and bacteria that make this unique local bread possible. The yeast is distinguished by its tolerance of acetic acid and its inability to ferment maltose. The bacterium (previously undescribed) produces acetic acid and will not grow without maltose. Other unusual nutrient and growth characteristics help explain why previous attempts to use San Francisco starter doughs elsewhere have been unsuccessful. Conditions were found which permit holding the starter doughs as long as five days, rather than the traditional 8 to 10 hours. This breakthrough has several implications, from broadening the base of manufacture of sour dough breads to a national level to a means of imparting good flavor characteristics in new short-term fermentation products that would otherwise be dull and unattractive. Judging by the consumption of bread in San Francisco, this work promises to greatly enhance the use of wheat nationally.

Thin-hulled Brown Stripe Safflower Oil. Higher yields of oil and protein from a new variety of safflower seed may be realized, due to processing research by Department scientists. A few years ago a new brown-striped variety of safflower had almost achieved commercial production when it was found that dark colors and bad odors developed in the oil during production and storage. The seed had a thin hull and thus had a higher content of oil and protein than commercial varieties. Moreover, in Arizona at least, the yield per acre of this new seed was similar to that of ordinary safflower, so that yields of oil per acre could be increased by as much as 25%, and the protein content of the meal was improved. Improved processing procedures have now been found, using existing plant equipment for production of light colored, odorless oil. Color precursors can be removed from the new safflower by refining or degumming before the oil is heated. The secret of removing odor-causing compounds (low molecular weight fatty acids and non-saponifiable fractions) is to use a heavier than normal bleach with a highly active clay. These research results show that brown-stripe seed may be produced and processed or that the seed may be used in breeding programs to develop even higher yielding types of safflower.

Processed Hawaiian Fruits for Mainland Markets. Department scientists, in cooperation with the Hawaii Agricultural Experiment Station, have made considerable progress during the past few years in developing high quality processed products from Hawaiian-grown tropical and subtropical fruits in order to diversify an agriculture which has been primarily devoted to sugar cane and pineapple. The concept for slicing, peel removal and seed separation from papaya was tested by Department scientists, and a prototype machine was built with the aid of Experiment Station agricultural engineers. This is now in commercial operation. The puree has a superior flavor because it contains no bitter taste from the peel, and is used for jam and jelly products. Techniques also were developed for guava puree production and storage stabilization. Guava puree is remanufactured into a variety of

products such as beverages, dairy products, jams, and jellies. Two new banana products resulting from Department research have been produced commercially, thus demonstrating the technical feasibility of the processes. A banana puree, stabilized for several weeks storage at 45° F. is useful in bakery and dairy products. The second product is osmo-vac dried banana, which has been used as a chocolate-coated confection. These new stable forms of tropical fruits will open markets all over the world for these delicious commodities, to the benefit of consumers and manufacturers, and will provide a broader base for Hawaiian agriculture.

A New Blend Durable-press Slack Fabric. A new blend durable-press slack fabric containing adult mohair has been experimentally produced by Department scientists. This development is of timely significance because of its potential of providing a stable new market in the casual slack field for adult mohair. Adult mohair is currently at a drastically low price and consequently heavily subsidized by government incentive payments to growers. Department research has shown that adult mohair, a hard-to-process, coarse fiber, can be spun on conventional worsted processing machinery in a blend with polyester and rayon. These new mohair blend fabrics are attracting commercial interest as exciting new materials for durable-press slacks with unusual aesthetic and wear properties. Because of low felting shrinkage potential of mohair no shrink-resist treatment is required. Fabrics can be processed by conventional delay-cure cellulosic crosslinking treatment.

Freon Freezing of Fruits. Strawberries frozen in cold air have a mushy texture, which reduces the market for frozen berries. Peaches frozen in cold air often show discoloration as well as poor texture. Fast freezing in liquid nitrogen has been shown by Department scientists to preserve a firmer texture, but the process is expensive. Now they have found that freezing in liquid Freon-12 at -22° F. produces a firm-textured product similar to that frozen in liquid nitrogen, but at less cost. Freezing in liquid nitrogen costs 1-1/2 - 3 cents per pound, compared to about 1 cent per pound for Freon freezing and 1/2 - 1 cent per pound for ordinary freezing. Commercial scale experiments, now under way, are expected to confirm the texture and cost advantages of Freon freezing. If so, this process could supply the market with higher quality frozen fruits with little difference in cost.

Citrus-based Low Calorie Sweeteners. Department scientists, studying ways to reduce bitterness of citrus products, discovered that they could convert two bitter components, naringin, found in grapefruit, and neohesperidin from bitter oranges, into extremely sweet compounds. The one from the grapefruit constituent is about one-third as sweet as the well known synthetic sweetener saccharin, or 100 times sweeter than ordinary table sugar. The one from bitter oranges is about 7 times sweeter than saccharin. A third new sweetener was prepared from the tasteless compound, hesperidin, which is the major flavonoid constituent of lemons and sweet oranges. The sweetness of all these citrus-based products is pleasant and long-lasting. A further great advantage is that none of these products has shown any

evidence of toxicity in preliminary studies on animals. The commercial availability of naringin and hesperidin as byproducts of the grapefruit and orange processing industries has evoked the interest of a large number of chemical, food, and drug companies in manufacturing a noncaloric sweetener from them. This interest has recently been heightened by concern about alleged toxic effects of cyclamate. Possible applications of citrus-based sweeteners are foreseen in pharmaceutical preparations, toothpastes, chewing gums, foods, and beverages. The Department has now produced pilot quantities of the sweeteners so that it may make long term feeding tests to demonstrate fully the safety of the products.

Breads from Feed Grains. Formulas have been found to make very acceptable raised breads from barley or milo flours. These feed grains are cheap and nutritious. This work gives promise of providing acceptable new foods from grains now used only relatively inefficiently in meat production. The barley or milo flour is mixed with a very small proportion of a soluble gum, mixed into a thick batter, and pan baked. Firm, light-colored, domed loaves are the result. Conventional proofing and baking are used. All conditions, except provision of the gum, are consistent with village conditions. If more of the world can be introduced to loaf bread in this way, the world use of normal bread grains may increase substantially in the long run.

WHEAT UTILIZATION

USDA and Cooperative Program

Problem Area		Scientist Man-Years		
		F.Y. 1969 (Estimated)		
No.	Title and Activity	Intra-mural	Extra-mural	Total
406	New and improved food products from field crops			
	Chemical composition and physical properties	6.1		6.1
	Flavor	2.2	0.6	2.8
	Technology--process and product development	4.8		4.8
	Subtotal	13.1	0.6	13.7
407	New and improved feed, textile and industrial products from field crops			
	Technology--process and product development	0.8		0.8
	Subtotal	0.8		0.8
601	Expansion of foreign markets for U.S. farm products			
	Chemical composition and physical properties		0.6	0.6
	Color, texture and other quality factors	5.2		5.2
	Technology--process and product development	10.1		10.1
	Subtotal	15.3	0.6	15.9
	TOTAL	29.2	1.2	30.4

Domestic program supplemented by P.L. 480 funds in 2 countries, totaling 30,600 U.S. dollars equivalent (India, England).

Problems and Objectives

The dominant feature of the wheat economy in the United States is a production capacity that can outpace consumption. Research on utilization of wheat seeks to solve the problems hindering the development of markets for the full productive capacity of U.S. agriculture. The emphasis is on expanding overseas dollar markets for U.S. wheats; developing new wheat food products for long-term market development in food-short nations abroad; raising the domestic consumption of wheat foods by increased variety, quality, and convenience; finding means to upgrade wheat millfeeds to recover fractions of nutritious food quality; and developing new and improved feeds from wheat.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Improving baking properties of bread flours by controlled maturation acceptable in European countries.
2. Developing protein-enriched export foods from wheat flours and millfeed fractions and concentrates.
3. Improving quality of continuous-mix baked goods.
4. Improving quality retention in frozen fermented bread doughs.
5. Developing processes to enhance the nutritive value of wheat for ruminant, poultry and swine feeds.

Progress - USDA and Cooperative Programs

RPA 406 - NEW AND IMPROVED FOOD PRODUCTS FROM FIELD CROPS

Chemical Composition and Physical Properties

Interaction of dough components. Work has continued on the alpha-gliadins, which are fibril-forming, shear-sensitive, and heat stable. Two electrophoretically homogeneous components have now been isolated. Two albumins also have been isolated. They are closely similar in electrophoretic behavior but differ two-fold in molecular weight; they occur in common, but not in durum wheats. Study of alpha- and beta-purothionins showed both to be small and compact in aqueous solutions. No specific features were found to account for occurrence of purothionin in lipoprotein complex. Phospholipids, divalent metal ions, and proteins were shown earlier to form complexes selective for all three parts. Marked variations in residual activity of alpha- and beta-amylases and lipoxidase are found after treatment of soluble proteins of flour with different combinations of phospholipids and metal ions.

Supported by P.L. 480 funds, the Flour Milling and Baking Research Association, England, is conducting research on the binding of lipids to starch and proteins in dough. Work on purification of proteolipids of flour by several techniques has resulted in substantial separations of "free" and "protein-bound" lipids. The findings of this and other work in which different reagents were used to split the lipid-protein bonds show that even in this highly polar protein of low molecular weight, several types of binding are present. Similarities and differences between the purothionins of wheat and hordothionins of barley have been described in detail; similar components were not detectable in the flours of rye, oats and maize. Differences in fatty acid composition between "bound" lipids of gluten, starch and water-soluble fractions of dough are usually much greater than differences within each fraction for different varieties, although significant varietal differences occur.

Flavor

Bread flavor. Of the volatile organic acids extractable from bread crumb or dough by means of acetone, most is acetic acid. In conventional-type doughs and breads, acetic acid comprises up to 75% of the total; propionic is the next most abundant acid. In sour French doughs and breads, acetic acid accounts for only about 50% of the total extracted acidity, but the total acidity is five to ten times that of conventional-type doughs and breads.

Color, Texture and Other Quality Factors

Character of doughs. In contract research at Stanford Research Institute, California, methods and apparatus were developed for determining the large deformation and rupture properties of wheat flour doughs in simple tension. Stress-strain curves were obtained from a medium strength and weak flour dough. Tensile properties of each dough were represented by 4 characteristic functions, each dependent on only one of the variables: strain, time, temperature, water content. The two flours were different in (1) range of linear isochronal stress-strain, (2) magnitude of exponent n in modulus $F(t,T,W)$, (3) magnitude and temperature dependence of moduli, (4) activation energies. Doughs under very small strains were observed in a dynamic rheometer. Covalent intermolecular crosslinking among proteins in dough was found to be of a low order. Starch granules interacted to form extensive, though not permanent aggregates which contributed importantly to practical dough properties.

Supported by P.L. 480 funds, the Bread Institute of Australia conducted research on the viscoelastic properties of doughs. For very small strains, viscoelastic behavior of dough was linear, i.e., storage and loss moduli were independent of shearing stress. At larger strains, pronounced non-linearity was observed with softening of the dough. Stress relaxation behavior could be derived for times as low as 0.001 second. Temperature effects were studied; a temperature-frequency superposition principle was

established. Similarly, a principle of corresponding water absorption was established. Dynamic properties of various gluten-starch-water systems were examined. The complicated dependence of the linear viscoelastic behavior of these systems is interpreted in terms of interactions between protein chains and starch granules and in terms of network theory adopted from studies of synthetic polymers. Departure from linear viscoelastic behavior and dough softening as strains were increased indicates progressive rupture of (non-covalent) bonds between protein and starch granules. Ample evidence suggests that starch is not merely an inert filler and that the nature of the starch granule surface, particle size distribution of granules, and granule damage are important factors.

In contract research conducted at the IIT Research Institute, Illinois, structural elements in flours and possible changes during dough formation from several wheat flours and doughs were examined by light microscopy, transmission electron microscopy (TEM), scanning electron microscopy (SEM), and X-ray diffraction. X-ray diffraction revealed no new information. Light microscopy indicated that some starch exudes from granules during dough formation. Special methods were developed for embedding, sectioning, fixing, and staining samples prior to electron microscopy. Protein bodies were infrequent in mature seed tissues. Ribosomes were sometimes associated with portions of endoplasmic reticulum that had remained unchanged during maturation. Best TEM results were obtained with high protein air-classified flour. No successful localization of phospholipid material in flours could be obtained by TEM. SEM revealed greater detail of general physical structures. Protein material could be seen adhering to starch granule surfaces. Lipid extraction of flours caused changes in the matrix material. The occasional structural elements found in flours by TEM were not seen by SEM. Even at 25,000X no fine structure was seen in lyophilized gluten films.

Technology--Process and Product Development

Effects of starch components on baking quality. Relatively mild chlorine treatment of wheat starch (0.25 to 1.0 oz./cwt.) increased viscosities of concentrated suspensions at room temperature and dilute pastes during heating in an amylograph, suggesting surface modifications and gentle loosening of granule structure allowing more water to be held at lower temperatures. High levels of chlorine (above 4 oz./cwt.) have been shown by other workers to degrade granule structure, reducing suspension viscosity. Chlorine dioxide treatment (1.0 to 2.0 g./cwt.) did not affect suspension viscosity, but did increase hot-paste viscosity.

Flours prepared from blends of the various treated starches with protein concentrates exhibited modified dough and bread properties usually attributed to changes in protein components. These results suggest that surface modification of the granules affects not only their gelatinization characteristics but also the gluten matrix emmeshing them.

Frozen fermented dough quality. Examination of sour dough French bread fermentation has revealed separate rising and souring mechanisms. Rising is correlated with counts of an unusual strain of Torulopsis yeast, isolated from 4 different commercial sources. This yeast does not ferment maltose, grows well in the presence of Actidione (which completely inhibits the growth of most yeasts) and shows unusual vigor under the particular acidic environment of sour dough. The bacteria probably responsible for acid formation are visible microscopically in numbers greatly exceeding those of the yeast cells but have resisted isolation on numerous and varied types of media.

RPA 407 - NEW AND IMPROVED FEED, TEXTILE AND INDUSTRIAL PRODUCTS FROM FIELD CROPS

Technology--Process and Product Development

Ruminant feeds. Dry heat expansion or "popping" has been investigated as a process to improve the digestibility of cereal grain in high-concentrate feedlot rations. In vitro data for different processing conditions show greatest starch digestibility is associated with highest initial moisture levels and greatest degree of expansion. Popped grains have an in vitro starch digestibility, greater than raw grains but lower than atmospheric-steamed and rolled or pressure-cooked and rolled grains. Popping does not increase the amount of water soluble material nor decrease the apparent availability of lysine, but does lower the amount of extractable protein. An in vivo cattle fattening test showed that steers fed popped milo or popped wheat performed about the same as those fed atmospheric-steamed and rolled and pressure-cooked and rolled grains. No significant differences could be detected in measures of feedlot response such as gains and feed efficiencies or in carcass characteristics. Commercial production has begun on a grain popping machine capable of handling 4 tons of grain per hour.

RPA 601 - EXPANSION OF FOREIGN MARKETS FOR U.S. FARM PRODUCTS

Chemical Composition and Physical Properties

Oxidation-reduction enzymes of wheat. Under a research grant, the University of Wisconsin is conducting research on the oxidation-reduction enzymes of wheat. Both peroxidase and polyphenoloxidase systems were found to (1) react with the lysine or methionine in model peptides or proteins, and (2) induce a modification of polymerization of wheat proteins. In addition to the enzyme and soluble protein, hydrogen peroxide and a hydrogen donor were required for modification of the model proteins. Evidence to date suggests that peroxidase-induced changes may involve formation of covalent bonds and that sulfhydryl groups do not participate. Some of the lysine residues were enzymatically oxidized to alpha-amino adipic-delta-semialdehyde. Model proteins high in methionine yielded ethylene, but those low in methionine did not in the peroxidase-dependent reactions.

Pentosans of wheat. Supported by P.L. 480 funds, the Swiss Federal Institute of Technology is conducting research on the relation of soluble pentosans and associated proteins to rheology of wheat. Pentosan-containing material capable of gelling with H_2O_2 is precipitable from water extracts of flour by both 25% and 35% (W/V) ammonium sulfate. Higher concentrations do not give active material. Unlike active fractions from DEAE cellulose the ammonium sulfate fractions which gel are relatively free of galactose. The main sugars are xylose and arabinose. Experiments with Pronase-treated pentosan preparations showed that some native polypeptide, probably covalently linked to the arabinoxylan, is necessary for gelation. However, if extra protein is added, it can become involved in the gel structure to give stronger gels. With caffeoyl guaran, protein is not essential for gelation; but if added, is linked to the polysaccharide upon oxidation in the presence of calcium, probably through chelate bridges of the type postulated earlier. A successful method was devised for synthesis of homovanillic acid in 50% yields, but attempts to synthesize homovanillyl guaran have so far failed to give a product capable of gelling upon oxidation.

Wheat-bran pigments. In contract research completed at Oregon State University, pigments were shown to be very complex proteinaceous polyphenolics. Nitrogen contents of dioxane-water extracted pigment correspond to 45% protein for red bran and 75% for white bran. Amino acid patterns of hydrolysates were similar to those of proteins, and resistance to hydrolysis indicates strong, probably covalent, bonding between protein and polyphenolic portions. Proline content was high; S-amino acids absent. Gel filtration provided fractions of M.W. 1500 and 20-50,000, both contained nitrogen, neither were homogeneous. Red and white bran pigments yielded somewhat different oxidation products, indicating differences in polyphenolic architecture. Absence of flavonoids and carotenoids, presence of 5-n-alkyl resorcinol in bran pigments was confirmed. Components with 1,2,4- and 1,3,4-benzoyl or cinnamoyl structures were found in polyphenolic pigments from both red and white brans. There were more similarities than differences between pigments of the two brans. The largest difference was in ratio of protein to polyphenolics. Darker pigmentation of red brans is probably due to higher proportion of polyphenolics. The nature of pigments is such that extensive studies would be needed for elucidation of structural details.

Color, Texture and Other Quality Factors

Wheat flour maturation. Hydrogen sulfide, released from doughs mixed under nitrogen and easily oxidized by dough maturing agents, did not have its source exclusively in gluten, water-soluble, or lipid constituents of flour, but partially in all three on the basis of reconstitution experiments. Brief exposure to a bronze bowl during dough mixing in air (prior to separation of gluten, etc.) decreases the amount of hydrogen sulfide released upon reconstitution (in a stainless steel bowl, under nitrogen). Wheat lipoxidase, involved in the oxidation of free fatty acids and sulfhydryl groups in doughs mixed in air, has been found to be most active from pH 5.5 to 6.8,

in contrast to soybean lipoxidase, at pH 7.2 to 9.0. Other differences also have been found. Extractable phosphorus has been determined; the patterns of change for both protein and phosphorus appear to be related to mixing characteristics of doughs. Wheat flour hemicelluloses are rapidly degraded by chlorine, which is used to treat cake flours. Difficulty in removing chlorine from the dry hemicellulose after treatment has prevented precise control of treatments, but the pattern of degradation appears to be the same as reported for wheat straw hemicellulose. Both are arabinoxylans; the latter has fewer arabinose side-chains or branches.

Technology--Process and Product Development

Protein-rich wheat products. Storage of Flour Blend A at high temperature and moisture gave rapid free fatty acids development, off-flavors, and loss of loaf volume when baked. Product stability was greatly enhanced by reducing moisture content from 13 to 10%. Off-flavors were attributed to formation of lipid-associated bitter material and free fatty acids in the Wheat Protein Concentrate (WPC) component. A lipase assay method is being used to gage the effectiveness of dry heat treatment on WPC to increase its stability. Protein-rich Wheat Soy Blend (WSB) was characterized as to composition, nutritional quality, and wholesomeness. Six-month storage stability of WSB was satisfactory for anticipated uses. Pearled wheat for export markets is being studied as to production, uses, composition and storage stability. Abrading off 20% of the wheat kernel in a CeCoCo Barley Pearler leaves an attractive rice-like product of 1.2% fiber content, but still retains a large portion of germ and other outer tissues rich in vitamins, minerals and protein. An Oakes Mixer allows preparation of more concentrated flour slurries without gluten development. This improvement in the WU-Modified Fesca Process for separation of protein and starch in flours obviates use of the gluten modifying agent ammonium hydroxide with hard wheat flours and reduces drying costs.

Investigation of the effect of a limited range of hydro-thermal treatments on phytic acid content of wheat fractions showed that significant reductions were accomplished. Atmospheric steaming of wheat and barley at various moisture levels was studied in order to develop adequately processed cereal bases for protein-fortified, gruel-like foods for infant and child feeding programs.

Publications - USDA and Cooperative Program

RPA 406 - NEW AND IMPROVED FOOD PRODUCTS FROM FIELD CROPS

Chemical Composition and Physical Properties

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RPA 407 - NEW AND IMPROVED FEED, TEXTILE AND INDUSTRIAL PRODUCTS FROM FIELD CROPS

Technology--Process and Product Development

- ROCKWELL, W. C., LOWE, E., WALKER, H. G. and MORGAN, A. I., JR. Hot air grain popping. Feedlot, Vol. 10 (1968) 42.

RPA 601 - EXPANSION OF FOREIGN MARKETS FOR U.S. FARM PRODUCTS

Chemical Composition and Physical Properties

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PAINTER, T. J. and NEUKOM, H. The mechanism of oxidative gelation of a glycoprotein from wheat flour. Evidence from a model system based upon caffeic acid. Biochim. Biophys. Acta, Vol. 158 (1968) 363-381.

Color, Texture and Other Quality Factors

MECHAM, D. K. and BEAN, MAURA, M. The release of hydrogen sulfide during dough mixing. Cereal Chem., Vol. 45 (Sept. 1968) 445-53.

RICE UTILIZATION

USDA and Cooperative Program

Problem Area		Scientist Man-Years F.Y. 1969 (Estimated)		
No.	Title and Activity	Intra- mural	Extra- mural	Total
406	New and improved food products from field crops Technology--process and product development	2.7	0.7	3.4
	Subtotal	2.7	0.7	3.4
901	Alleviate soil, water and air pollution Technology--process and product development		1.3	1.3
	Subtotal		1.3	1.3
	TOTAL	2.7	2.0	4.7

Domestic program supplemented by P.L. 480 funds in 1 country, totaling 12,900 U.S. dollars equivalent (Japan).

Problems and Objectives

The per capita consumption of rice in the U.S. has increased about 25% over the past ten years. Most of the increase has occurred through the use of processed products featuring convenience of use, especially quick cooking rice. Most of this product is made by processes which are inefficient due to rather large losses of solubilized solids and to kernel breakage. Final product cost is therefore higher than necessary. Also all precooked rice is made from long-grain rice, which is higher in cost than medium- or short-grain rices. The need is for new and improved food products with better nutritive quality and produced at minimum increase in cost. Such products must be easy to prepare; have good texture, flavor, and appearance; and be economical to manufacture. Also needed are drastically improved milling methods. Disposal of rice hulls is a major problem for the rice milling industry; methods for converting waste rice hulls to consumer products are needed.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Developing new processing methods for lower cost consumer products from short- and medium-grain rices.
2. Developing new products from waste rice hulls.

Progress - USDA and Cooperative Programs

RPA 406 - NEW AND IMPROVED FOOD PRODUCTS FROM FIELD CROPS

Chemical Composition and Physical Properties

Amylopectins of rice. The Nagoya University, Japan, supported by P.L. 480 funds, is conducting research to determine the biochemical and physical factors in the structure of amylopectic molecules of rice starch as they relate to processing characteristics. Partially purified starch synthetase from spinach leaves was bound with the amylose starch molecule. Binding was much stronger with non-glutinous than with glutinous rice starch. A suggested organ-specific substrate utilization is being examined, as is the specificity of adenosine diphosphate glucose (ADPG) as a glucose source for the soluble enzyme form compared with use of either ADPG or UDPG (uridine compound) by the granular form. Possibility of two isoenzymes may relate to their connection with mechanism of amylopectin biosynthesis. Starch breakdown in germinating seeds involves chiefly the amylolytic enzymes alpha-amylase and maltase; phosphorylase plays some role. The glucose derived from endosperm starch appears converted in the scutellum to sucrose which is mobilized to growing tissues. Stimulation of the granule-bound starch synthetase by potassium ion was shown for rice starch synthesis, but at a lower activity than in sweet potato starch. The specific role of potassium ion is being sought.

Technology--Process and Product Development

High-protein rice products. The University of California in Berkeley is conducting contract research to evaluate the cooking and processing characteristics, utility of new products, and optimum economic balance of products from white rice overmilled to various degrees. Planned extensive measurements of chemical and physical properties and cooking characteristics are almost completed on three flours prepared by abrasively removing consecutive surface layers of milled rice, and on the original and residual kernels for each of six varieties. Results showed much greater concentrations of protein, fat, vitamins, minerals, and phytic acid in the outer-layer flours, and quantified the differences by layer. Variations in physical and cooking characteristics generally were smaller.

New rice products. Alkaline extraction of defatted rice bran removed the majority of crude protein. Neutralization and drying readily recovered 50% of the bran protein as a 40% concentrate. Drying of solids precipitated from extract at pH 5.5 yielded 37% of bran protein as an 85% concentrate. Soluble and precipitated proteins contained multiple components. Sieving and remilling defatted rice bran on a Quadrumat flouring mill at various moisture levels yielded most flour (56%) and least coarse bran at lower moistures. Flour protein, also highest in dryest flours, increased about 2% over bran protein (14.5%); crude fiber decreased from 20% to 8%. Sieving the flour through 140 mesh yielded about 25% of original bran with 15.5% protein and 4.5% fiber, which has potential for food use. Amylograph viscosity measurements of regular and high-protein rice flours showed marked differences. Viscosities increased in the order: outer-, second-, and third-layer flours, original kernels, and residual kernels.

RPA 901 - ALLEVIATE SOIL, WATER, AND AIR POLLUTION

Technology--Process and Product Development

Conversion of rice hulls. Contract research on the conversion of rice hulls to specialty fuels and use of ash in water clarification has been initiated at URS Research Company, California.

Publications - USDA and Cooperative Program

RPA 406 - NEW AND IMPROVED FOOD PRODUCTS FROM FIELD CROPS

Chemical Composition and Physical Properties

TANAKA, Y. and AKAZAWA, T. Substrate specificity of the granule-bound and chloroplastic starch synthetase. Plant Cell Physiol. (Tokyo), Vol. 9 (1968) 405-410

MURATA, T. and AKAZAWA, T. Enzymic mechanism of starch synthesis in sweet potato roots. I. Requirement of potassium ions for starch synthetase. Arch. Biochem. Biophys., Vol. 126 (1968) 873-879.

Technology--Process and Product Development

- HOUSTON, D. F., IWASAKI, T., MOHAMMAD, A., and CHEN, L. Radial distribution of protein by solubility classes in the milled rice kernel. J. Agr. Food Chem., Vol. 16, No. 5 (1968) 720-724.
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FORAGE UTILIZATION

USDA and Cooperative Program

		: Scientist Man-Years		
Problem Area		: F.Y. 1969 (Estimated)		
No.	Title and Activity	Intra- mural	Extra- mural	Total
407	New and improved feed, textile and industrial products from field crops:	:	:	:
	Technology--process and product development	: 8.2	:	: 8.2
	Subtotal	: 8.2	:	: 8.2
601	Expansion of foreign markets for U.S. farm products	:	:	:
	Technology--process and product development	: 3.2	:	: 3.2
	Subtotal	: 3.2	:	: 3.2
	TOTAL	: 11.4	:	: 11.4

Domestic program supplemented by P.L. 480 funds in 1 country totaling 80,500 U.S. dollars equivalent (Israel).

Problems and Objectives

The demand for livestock in the United States will increase about 33% by 1975. Since forage crops constitute the major feedstuff for ruminant animals, the demand for forages will increase accordingly. In addition, there is an increasing demand for processed forages in European and Asiatic markets as well as in domestic markets. Fresh forage crops are the richest natural source of many nutrients for farm animals. However, up to 30-40% of the forages are lost during haymaking and ensiling. Dehydration is now the only practical means of producing products of high nutritional value in a form usable in manufactured feeds and supplements, but use of dehydrated products is restricted because of their high-fiber and growth-inhibitor content. New and improved products are needed for foreign and domestic markets.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Improving feeds from alfalfa and other forage crops.
2. Improving ruminant feeds from highly lignified fibrous agricultural materials.
3. Developing products containing standardized amounts of unidentified growth and reproduction factors (U.G.F.)
4. Developing new low-fiber products from forage crops for export markets.

Progress - USDA and Cooperative Programs

RPA 407 - NEW AND IMPROVED FEED, TEXTILE AND INDUSTRIAL
PRODUCTS FROM FIELD CROPS

Technology--Process and Product Development

Unidentified growth factor(s). Cooperative work with the Department of Nutritional Sciences, University of California, Berkeley, showed that guinea pigs require a U.G.F. found in alfalfa. Extracts were prepared which contained the active principle. The factor is soluble in aqueous alcohol and can be precipitated by adding acetone to an aqueous solution. The active principle is acidic in nature as determined by behavior on ion exchange columns. The factor is stable to freeze drying but somewhat unstable to commercial type dehydration. Whole alfalfa showed some effect in preventing sickness (of unidentified nature) in guinea pigs. In one experiment, most of the control guinea pigs died or lost weight apparently due to an unidentified infection while the lots receiving 10% dried alfalfa grew normally. An imitation alfalfa made of purified materials to simulate 20% protein alfalfa produced no growth stimulation while the dried alfalfa produced its

usual response of about 12-15% growth increase over controls. This showed that the activity was not due to amino acids, minerals, lipids, known vitamins, cellulose, pectin, or pentosans, in the proportions found in alfalfa.

Improved forage products. The principal epoxide xanthophylls in forage plants were evaluated and found ineffective for pigmenting broiler skin. A modified method of xanthophyll analysis which excluded the epoxide xanthophyll was therefore developed for mildly processed meals. Total xanthophyll content was found to be highest in forages just prior to flowering. Alfalfa harvested during the summer months contained higher levels of pigmenting xanthophyll than that harvested in the fall.

Improved nonruminant feeds. The aleurone layer of the wheat kernel is the key to nutrient utilization in wheat millfeeds. Only when the contents of these cells are digested can the full nutrient potential of millfeeds be realized. Ways to rupture aleurone cell walls and increase digestibility of the contents were studied. In vitro enzyme methods which correlate well with in vivo were developed to measure protein digestibility or availability in plant materials. Protein availability in wheat bran can be raised to 92% by severe milling techniques. Protein availability in other feeds like alfalfa also can be increased by processing.

Studies showed that the α -amylase inhibitor in wheat bran does not influence starch utilization by chicks.

A new method of analysis for starch in feeds was devised, and some previously unreported sugars were found in wheat bran. Apart from degree of starch gelatinization the carbohydrates of steam-pelleted wheat bran and unpelleted bran mash were essentially the same.

Alfalfa products. Contract research on the digestibility of fibrous fractions of alfalfa has been concluded at the University of Nebraska. Feeding trials with cattle and sheep showed the value to growing ruminants of alfalfa stem to be equal to that of chopped whole alfalfa. The amount of alfalfa consumed by ruminants was found to be proportional to the percent of the organic matter digested. Of several physical treatments tried, ball milling was the only one that increased the digestion of alfalfa stem substantially and it was considered not to be economically feasible. Sieving hammer milled alfalfa stem revealed that the amount digested increased as the particle size decreased. Alfalfa digestibility proved to be much more difficult to improve by chemical treatments than other fibrous products. It was better initially. Of 40 chemicals tested, sodium hydroxide gave the best results. Treatment of alfalfa stem with high pressure (up to 600 psi) steam gave promising in vitro results but the in vivo results were disappointing. The formation of a toxic principle is possibly the reason. These results support the practicality of separating dehydrated alfalfa into a leaf fraction for non-ruminant nutrition and a stem fraction for ruminants. The stem fraction can be hammer milled and separated into a fine fraction with

superior nutritive qualities for ruminants and a coarse fraction which might be economically improved by chemical and/or high pressure steam treatment. Any improvement made in digestibility is doubly important because of the corresponding increase in consumption.

Contract research on the effect of alfalfa fractions on utilization of urea by ruminants has been initiated at the Purdue Research Foundation, Indiana.

RPA 601 - EXPANSION OF FOREIGN MARKETS FOR U.S. FARM PRODUCTS

Chemical Composition and Physical Properties

Estrogen inhibitors. Supported by P.L. 480 funds, The Hebrew University, Israel, is investigating the nature of the estrogen-inhibiting factors in forages. An estrogen inhibitor has been found in 14 different plants. The inhibitor consists of two or more separate components. Coumestrol has been found in milk of cows fed alfalfa indicating that estrogen activity can be carried over from feed to human food.

Alfalfa saponins. Also supported by P.L. 480 funds, The Hebrew University, Israel, is studying the saponin components of alfalfa. Research on separation of individual saponins of alfalfa stems and leaves by ion exchange chromatography on DEAE cellulose and by exclusion chromatography (Sephadex) was not successful. Continuous flow electrophoresis yielded six reproducible fractions, one of which seemed homogeneous. The latter contained one aglycone, apparently medacagenic acid, and three sugars, glucose, galactose and arabinose. An improved bioassay procedure for saponins using larvae of Tribolium castaneum was developed. In this test the toxic effects of saponin are reversed not only by cholesterol but also equally well by sitosterol and campesterol. Stigmasterol and lanosterol were only partially effective.

Technology--Process and Product Development

Separation processes for alfalfa. Dry separation procedures based on air classification and screening have been developed for separation of dehydrated alfalfa into high-protein, low-fiber products for poultry and swine and high-fiber products for ruminants. By simple control systems the process may be adjusted to provide products ranging from 12% protein to 25% protein to meet specific market requirements. The process has been carried through the pilot plant stage into commercial production. A pilot plant for the wet processing of alfalfa has been installed. Sugar cane test rolls remove about 35% of the weight of fresh alfalfa as juice. This is heat-coagulated to give a green protein concentrate and a brown juice. The concentrate is drum-dried to a free flowing powder. It contains about 50% protein and 2-3 times more carotene-xanthophyll than fresh alfalfa. The brown juice contains the water soluble nutrients and can be flash evaporated to a molasses for use as a liquid feed supplement. The crushed alfalfa is dehydrated to a product which contains slightly less protein, carotene, and xanthophyll than present commercial dehydrated meal. This process is being commercially evaluated.

Publications - USDA and Cooperative ProgramRPA 407 - NEW AND IMPROVED FEED, TEXTILE AND INDUSTRIAL
PRODUCTS FROM FIELD CROPSTechnology--Process and Product Development

- BICKOFF, E. M. Oestrogenic constituents of forage plants. Commonwealth Bureau of Pastures and Field Crops, England, Review Series No. 1/1968.
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- LIVINGSTON, A. L., NELSON, J. W. and KOHLER, G. O. Stability of α -tocopherol during alfalfa dehydration and storage. J. Agr. Food Chem., Vol. 16 (1968) 492-95.
- KUZMICKY, D. D., KOHLER, G. O., LIVINGSTON, A. L., KNOWLES, R. E., and NELSON, J. W. Pigmentation potency of xanthophyll sources. Poul. Sci., Vol. 47 (1968) 389-97.
- KNOWLES, R. E., LIVINGSTON, A. L., NELSON, J. W., and KOHLER, G. O. Xanthophyll and carotene storage stability in commercially dehydrated and freeze-dried alfalfa. J. Agr. Food Chem., Vol. 16 (1968) 654-58.
- KNOWLES, R. E., LIVINGSTON, A. L., NELSON, J. W., and KOHLER, G. O. Stabilization of carotenoids by ethoxyquin in harvested fresh alfalfa. J. Agr. Food Chem., Vol. 16 (1968) 985-89.
- LIVINGSTON, A. L., SMITH, DALE, CARNAHAN, H. L., KNOWLES, R. E., NELSON, J. W. and KOHLER, G. O. Variation in the xanthophyll and carotene content of lucerne, clovers and grasses. J. Sci. Food Agr., Vol. 19 (1968) 632-36.
- SAUNDERS, R. M. Separation of sugars on an ion-exchange resin. Carbohydrate Res., Vol. 7 (1968) 76-79.
- SAUNDERS, R. M., WALKER, H. G., Jr., and KOHLER, G. O. The digestibility of steam-pelleted wheat bran. Poultry Sci., Vol. 47 (1968) 1636-37.

RPA 601 - EXPANSION OF FOREIGN MARKETS FOR U.S. FARM PRODUCTS

Technology--Process and Product Development

- CHRISMAN, J. and KOHLER, G. O. Separation milling of alfalfa. Proc. 10th Technical Alfalfa Conf., USDA, ARS 74-46 (1968) 37.
- KOHLER, G. O., BICKOFF, E. M., SPENCER, R. R., WITT, S. C., and KNUCKLES, B. E. Wet processing of alfalfa for animal feed products. Proc. 10th Technical Alfalfa Conf., USDA, ARS 74-46 (1968) 71.

WOOL AND MOHAIR UTILIZATION

USDA and Cooperative Program

		: Scientist Man-Years		
Problem Area		: F.Y. 1969 (Estimated)		
		: Intra- : Extra- :		
No. :	Title and Activity	: mural	: mural	: Total
411 :	New and improved products from wool,	:	:	:
:	hides, skins and animal fats	:	:	:
:	Chemical and physical investiga-	:	:	:
:	tions to improve products	: 23.1	:	: 23.1
:	Technology--process and product	:	:	:
:	development	: 12.4	: 0.7	: 13.1
:	TOTAL	: 35.5	: 0.7	: 36.2

Domestic program supplemented by P.L. 480 funds in 3 countries totaling 79,800 U.S. dollars equivalent (India, Germany, Israel).

Problems and Objectives

Traditional markets for wool and mohair have been lost to synthetic fibers because consumers prefer garments that hold their pleats and creases, resist shrinkage and wrinkling during washing, and dry quickly. Natural wool and mohair outclass the synthetics in tailorability, comfort in wear, appearance, and hand, but lack certain features now being exploited by the promoters of synthetics. Furthermore, some current processing methods damage, distort, or weaken wool and mohair fibers and injure performance and appearance of the fabric. We need processes that will modify natural fibers to give a range of comfortable and attractive fabrics that resist deterioration in processing and wear. New markets in industrial and other uses would develop for new types of fabrics, woven and non-woven, made from natural wools and from blends of wool with modified wools or other fibers.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Developing improved fabrics from wool and mohair blends.
2. Improving efficiencies in the processing of worsted wool and mohair yarns.
3. Developing treatments for wool and mohair products to decrease upkeep costs.

Progress - USDA and Cooperative Programs

RPA 411 - NEW AND IMPROVED PRODUCTS FROM WOOL,
HIDES, SKIN AND ANIMAL FATS

Chemical and Physical Investigations to Improve Products

Effects of physical and chemical structures. Fiber interactions which contribute to wool felting have been further explained. A major factor in the felting shrinkage of wool is the attraction between the fibers during washing. In natural wool this attraction is due to the hydrophobic nature of the fiber surface. All chemical shrinkproofing treatments make the fiber surface less water repellent, thus diminishing the attraction between fibers in aqueous media. Voltage pulses occurring during alpha helix melting have been postulated and confirmed. Scanning electron microscopy has been applied to normal and treated wool fibers, and show significant variations with nature of treatment. Deposition by the WURLAN process with adequate removal of excess free liquid from the first stage of treatment gives relatively few and small deposits of free polymer in capillary spaces between fibers. Occurrence of polymer bridges between fibers is evidence for treatment of the material in fabric form. Polyurea coatings showed small craters, not seen with polyamide. Deposits of vinyl polymers formed by photopolymerization were less uniform and were concentrated near scale edges.

On the other hand, corona discharge in the presence of dilute chlorine appears not to change the dry wool or mohair surface texture. Wear trials on durable press treated wool-cellulosic blends have established optimum component proportions. Computerized data reduction has been applied to "hand" panel data, fabric design, and sliver unevenness.

Easy-care treatments. Soluble proteins were crosslinked to wool with diepoxides, producing shrinkproof fabrics with enhanced strength, abrasion resistance and dyeability. Novel nonwoven fabrics made from wool fibers with modified polyurethane binders had good tear strength, wrinkle recovery, and were shrinkproof. A method was found for grafting any water-soluble monomer onto wool, using catalytic quantities of hydrogen peroxide, which with the wool forms a redox system. Reproducible results were obtained for grafting 10 to 100% polyacrylic acid. Equipment was assembled for generation of radio frequency low temperature plasma and exploratory work on wool was begun. Other studies included crosslinking of polymers onto wool, cellulosic coatings for wool, and reaction of wool with cotton-crosslinking agents. Crease retention in wool is tremendously increased by modification with 20W% of phenyl isocyanate. Relation between crease retention and chemical modification is being studied. Treatment of wool with halogenated compounds greatly improved flame resistance. Fluoropolymers and copolymers which were oleophobic and mildly hydrophilic were synthesized for use as soil-releasing protective finishes. Wool was bleached rapidly by exposure to high-intensity visible light, and the effect was more durable than comparable chemical bleaching.

Adsorption of selected ions. The Ahmedabad Textile Industry Association in India, supported by P.L. 480 funds, is continuing its study of the adsorption of selected inorganic ions onto wool fibers. The adsorption is found to localize, one ion per site. Wool oxidized with periodic acid has sulfonic acid groups. This results in (1) a lowering of the isoionic pH and (2) increased adsorption of sodium ions, that is, oxidized wool behaves more like a cation exchanger.

Chemical effects on fiber crimp stability. Supported by P.L. 480 funds, The Institute for Fiber and Forest Products Research in Israel has extended its evaluation of geometrical and energetical crimp properties, as well as associated physical properties to cover 34 different types of wools. The static parameters at a load of 10 mg. show stronger and more consistent correlations against fineness than do those at lower loads; coarser fibers are associated with higher crimp amplitude and greater length contraction. The most significant correlation among crimp parameters is between uncrimping energy and either the number of waves or the crimp ratio. No correlation was observed between the main static parameter (crimp diameter) and main dynamic parameter (uncrimping energy). In the wools tested for feltability the degree of feltability is found to be related to crimp ratio, uncrimping energy and extensional forces but not with fiber fineness. The wools with fibers of high crimp ratio felted easier, and those requiring more energy to uncrimp felted less easily.

X-ray diffraction patterns. Supported by P.L. 480 funds, the German Wool Research Institute, West Germany, has experimentally verified the theoretically postulated 198 Å meridional reflection in both wool and mohair fibers. The fact that the intensity of this reflection can be altered by chemical treatment, and varies with the type of wool was demonstrated. The effect of staining the carboxyl group on the equatorial X-ray reflections was investigated. Heavy atoms, such as bromine and iodine, are particularly effective. The effect of detergent molecules on the molecular structure of wool was studied. The amount of detergent absorbed increases when the disulfide bonds are broken.

Sulfur in wool keratins. Research supported by P.L. 480 funds at the Karolinska Institute in Sweden has been concluded. X-ray microanalytical studies of hair follicles were pursued. Sulfur is incorporated in the region where filament bundles (fibrils) form, between 300 and 700 microns from the base, but incorporation stops where bundle growth stops. That sulfur is incorporated as a sulfur-rich matrix distinct from the filaments is questioned.

Technology--Process and Product Development

Blends of wool and other fibers. Excellent durable press (DP) performance in wool/cellulosic blends combined with significant decrease in yellowing compared with conventional dihydroxydimethylol ethylene urea (DHDEU) was achieved with a modified methylol imidazoline reactant. Tri-blend fabrics of both adult and kid mohair with high wet modulus (HWM) rayon and polyester were experimentally manufactured and show promise as DP men's slack fabric. Aziridine-blocked, isocyanate prepolymers, which show promise in a one-step process for combination shrink-resist and durable-press treatment of wool/cellulosic blend fabrics, were evaluated on a pilot scale.

Oil-water repellents for wool. In contract research at the Harris Research Laboratories, Maryland, new fluoropolymers which gave good oil and water repellency on fabrics were tested further in dilution with nonfluorinated extenders. A rapid method for determining liquid repellency or critical surface tension of fluorochemical-diluent mixtures was developed. Poly-(fluorooctyl) acrylate (PFOA) was the most effective polymer found for obtaining the low energy surfaces required for high repellency. A poly-(fluoro-siloxane) was almost as effective and far less expensive. Laundering and drycleaning tests showed that PFOA had good durability in drycleaning and laundering. Although the fluoropolymer-diluent mixtures provided good oil and water repellency, soiling and soil-removal tests showed that these finishes increased soil deposition and reduced soil removal in laundering.

Interfacially applied resins. A unique, batch shrink-resist treatment for wool knitwear, the "Wur-knit" process, is in development stage. The Wur-knit process, which is based on the interfacial application of a resin finish, offers the promise of an important new practical method for the

stabilization of wool knitwear for machine washable and dryable garments. Not only does the process insure fully relaxed, stable dimensions, but it is potentially applicable to a wide range of knitted constructions independent of wool quality, yarn twist and knit loop length. The process is carried out by a centrifuging technique in contrast to the more conventional dip-and-pad procedure for continuous Wurlan fabric treatment. Knitted sections are impregnated in an aqueous reactant, centrifuged to remove excess liquor, immersed in the solvent reactant, centrifuged once again, scoured and tumble-dried. Consolidation and complete relaxation of the knit structure occur during processing without distorting the clarity of the knit structure. Among the treatment variables which have been optimized are methods and sequence of application, immersion times and temperatures, and reactant concentrations. In addition, analysis procedures for reactants, stability of the treating solutions, effect of the treatment on subsequent dyeing, and effect of after-dyeing on shrink-resistance have been investigated.

Wool/cotton fiber blends. The Texas Technological College is conducting contract research on blending wool/cotton fibers on cotton processing system. Preliminary work indicates that with minor adjustments and modifications some cotton processing machinery can be used for the processing of wool and wool/cotton blends. Some roving and yarn have been made and small samples, mainly of wool/cotton blends are being analyzed.

Surface fine structure of wool and mohair. Contract research on the surface fine structure of wool and mohair has been initiated at the Textile Research Institute, New Jersey.

Publications - USDA and Cooperative Program

RPA 411 - NEW AND IMPROVED PRODUCTS FROM WOOL,
HIDES, SKIN AND ANIMAL FATS

Chemical and Physical Investigations to Improve Products

- MENEFEE, E. A mechanical model for wool. Textile Res. J., Vol. 38, No. 12 (Dec. 1968) 1149.
- O'CONNELL, R. A., PARDO, C. E. and FONG, W. Preliminary observations on durable press wool blend fabric. Amer. Dyestuff Rpt., Vol. 57, No. 8 (Apr. 1, 1968) 17-19.
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- PARDO, C. E., O'CONNELL, R. A., and FONG, W. Woolen blend durable press fabric. Amer. Dyestuff Rptr., Vol. 57, No. 23 (Nov. 1968) 43-48.
- THORSEN, W. J. A corona discharge method of producing shrink-resistant wool and mohair. Part II: Effects of temperature, chloride gas, and moisture. Textile Res. J., Vol. 38 (1968) 644.
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CITRUS AND SUBTROPICAL FRUIT UTILIZATION

USDA and Cooperative Program

Problem Area		Scientist Man-Years		
		F.Y. 1969 (Estimated)		
No.:	Title and Activity	Intra-mural	Extra-mural	Total
403:	New and improved fruit and vegetable products	:	:	:
:	Chemical composition and physical properties	6.5	0.2	6.7
:	Flavor	2.0	:	2.0
:	Technology--process and product development	4.5	0.3	4.8
:	Subtotal	13.0	0.5	13.5
901:	Alleviate soil, water and air pollution	:	:	:
:	Technology--process and product development	0.9	:	0.9
:	Subtotal	0.9	:	0.9
:	TOTAL	13.9	0.5	14.4

Domestic program supplemented by P.L. 480 funds in 1 country totaling 7,800 U.S. dollars equivalent (India).

Problems and Objectives

The economic stability of the citrus and subtropical fruit industries in the Western Region is dependent upon effective utilization of fruit that cannot be accommodated on the fresh fruit market. Ineffective utilization of products is continuously increasing processing costs and resulting in decreased returns to the grower. Also, deterioration of flavor and color in processed citrus and subtropical fruit products imposes severe limitations upon the economic stability of the industry. New and improved fruit products are needed. The reduction of water pollution is another critical problem for the fruit processing industry. Needed are methods for processing brines so as to reduce the effluent salt contents of processing plants.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Improving stability and flavor of non-frozen fruit juice concentrates and purees.
2. Developing citrus products with improved flavor, color, and stability.
3. Processing mechanically harvested dates.
4. Developing sweeteners from citrus flavonoids.
5. Controlling pollution and converting waste products.

Progress - USDA and Cooperative Programs

RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

Chemical Composition and Physical Properties

Constituents of citrus and citrus products. A number of new flavanone neohesperidosides together with the corresponding dihydrochalcone neohesperidosides have been synthesized and evaluated for taste properties. Although all of these dihydrochalcones (DHC) are sweet, none is considered to be especially superior to older DHC's from a practical point of view because of the difficulties involved in their synthesis. Work on structure-activity relationships in this series is continuing. A nuclear magnetic resonance study of C-glycosylflavones has been completed; the results enable one to distinguish 6-substituted from the 8-substituted flavones.

In work on the characterization of lemon and orange juices, individual phospholipids were separated, identified and measured. Lemon maturity and storage had little effect on total and individual phospholipids, inorganic phosphorus, nucleic acids and protein phosphorus. Two new

carotenones, semi- α -carotenone and triphasiaxanthin, were isolated for the first time from Citrus relatives. These deep-red pigments contribute to the rich color of citrus fruits. Another carotenoid was isolated and given the tentative structure β -carotenone-5,6-diol. It is probably the precursor of semi- β -carotenone. It was discovered that limonin causes bitterness of commercial lemon juice. Thus, it is now known that lemon juice undergoes delayed bitterness in the same manner as navel orange and grapefruit juices. Grapefruit juice also suffers from naringin bitterness. Naringin was found to accumulate in the fruit mainly during early growth and its synthesis appeared to be controlled by phenylalanine ammonia-lyase activity.

Factors affecting quality of mechanically harvested dates. Contract research at the University of California, Riverside, on tenderizing mechanically harvested dates has been concluded. Parenchyma cell wall dissolution accompanies preharvest softening, which is postulated to follow through enzymic action if sufficient water is present. Vascular systems remain intact, permitting sugar accumulation. Firm dates have low moisture and many intact cell walls. Post harvest softening was accomplished by hydration and incubation and was accompanied by cell wall dissolution. The results emphasize the need to deliver adequate moisture into, rather than to, the date and emphasize the critical need of separating soft dates from firm dates so that an adequate treatment can be given to the firm date. If soft dates are present, the structurally weak mass of tissue will be converted into a mass of fluid. The information gathered under this project now provides a clear understanding of some of the important anatomical and chemical changes that occur during development, preharvest softening, post harvest softening, and the differences that exist between firm and soft dates. This work also provides a clear set of conditions that must be maintained and/or determined for success in post harvest tenderization of firm Deglet Noor dates. In addition, the results of this project point up the need for studies of the enzymes and regulatory mechanisms that control the anatomical and chemical changes that lead to soft, tender dates.

Flavor

Processed fruit flavor. The modified WURVAC process can produce 1000-fold essence concentrated directly from single-strength orange and apple juices. Flavor fortification was accomplished by the direct condensation of 1000-fold essence on orange powder. When essence was added at the level in the original juice, moisture content of the powder was increased from 2.6 to 3.0%. The added essence could readily be detected in the powder. Ease with which essence compounds are extracted from aqueous solutions was studied. Orange essence was concentrated several thousand-fold with liquid carbon dioxide. Pineapple mill juice was concentrated from 10% to 42% solids by reverse osmosis. The concentrate is being evaluated as a syrup ingredient.

Supported by P.L. 480 funds, the University of Baroda, India, is conducting research on organic acid metabolism in citrus as related to flavor and

texture. All parts of the tissues of Citrus acida except juice (namely green skin, white skin, septa and vesicles) possess the glycolytic enzymes to convert glucose to pyruvate. They also possess the enzymes involved in the conversion of glucose to ascorbic acid. In the early stages of development, glycolysis and ascorbic acid synthesis are high, facilitating conversion of glucose to ascorbic acid via glucose-1-phosphate and d-glucuronic acid. While glucose is utilized for respiration in young fruit tissues, glutamic acid formed by protein breakdown seems to be utilized for respiration in mature fruit tissues in which glucose is mainly used for citrate formation. Cell-free extracts of fruit tissues possess glutamate dehydrogenase activity which brings about conversion of glutamate to 2-oxoglutarate. Asparagine and glutamine synthetases which form asparagine and glutamine from aspartate, glutamate and ammonia have been detected. The activities of these enzymes are very high in mature fruit tissues.

Technology--Process and Product Development

Lemon oil stability. New and improved methods have been developed for the separation by gas chromatography of more than 100 volatile constituents in commercial California lemon oil. Work is in progress on the characterization of constituents which are responsible for the characteristic lemon flavor as well as the labile compounds involved in chemical changes which produce off-odors and off-flavors during storage of lemon oil and lemon-flavored products. Photochemical changes induced by exposure to light appear to play a prominent role in the development of off-odors and off-flavors in lemon oil. Irradiation of whole lemon oil as well as volatile fractions separated from the oil produced similar off-odors. The volatile fraction, containing labile terpene hydrocarbons, may be the principal source of off-odors in lemon-flavored food and beverage products exposed to light.

Desert grapefruit products. In contract research concluded at the University of Arizona, Tucson, improved grapefruit juice products were developed. These include mixtures of grapefruit juice with strawberry, raspberry, apricot and peach purees, low-calorie products of the same general types, fruit drinks based on grapefruit juice with whey as a component, and carbonated beverages containing natural fruit flavors based on grapefruit juice. Some of these products were evaluated by the USDA Special Surveys Branch in Washington, D. C. The top rated product was a juice drink whose primary ingredients were grapefruit juice (30.6%), whey (30.6%) and peach puree (25.6%). The product which the panel liked next best was a juice drink containing primarily grapefruit juice (61.2%) and peach puree (25.6%). Procedures were also developed for reducing the acidity of grapefruit juice and for minimizing the incorporation of the naringin and limonin bitter principles into grapefruit juice products.

Tropical fruit products. Unique flavor, color, and texture characteristics of many tropical fruits can be retained in stable products by applying proper processing techniques developed by WU scientists. The production

of superior, stable dried banana products has been demonstrated. The need for, and effectiveness of, enzyme inactivation and efficient separation of peel tissue from papaya puree was established. Processes for preparation of stable banana puree and tropical fruit syrups were devised. The effect of recommended processing operations on the residue of an insecticide on papayas was determined in cooperation with the Hawaii State pesticide laboratory. The effects of gamma irradiation on quality and stability of guava puree concentrate were determined. Concentrates of guava, papaya, passion fruit, pineapple, and Governor's plum juices were prepared and used for manufacture of high quality jellies and jams by mixing the required ingredients at pasteurizing temperature. Two new pieces of food processing equipment were devised in cooperation with the Agricultural Engineering Department at the Hawaii Agricultural Experiment Station and patent applications are to be made for a papaya peel separator and a mechanical banana pulp separator. Work on drum drying certain wastes from pineapple canning operations has shown indications of a possible solution to part of the industry's waste disposal problem.

Processing mechanically harvested dates. A combination of diverging roll sizer and resilience separator was 90% effective in separating mature and immature dates. Over-mature dates can be reconditioned by steaming below 140° F. Immature dates can be ripened by freezing, thawing, tempering for several days, and finally heating and drying at 100° F. After processing, artificially ripened dates closely resemble naturally ripened fruit. The effect of harvest time on overall quality was examined. Quality is maximized when 65-75% of the fruit is in the brown stage and the rest in the red stage. The brown fruit can be reconditioned to market quality and the red fruit can be artificially ripened.

Changes in the polygalacturonase (PG) activity during ripening and the relationship between this activity and the quality grade of Deglet Noor dates were studied. There was a significant increase in PG activity with ripening. PG activity, which was virtually absent at the green stage, rose sharply during the period that the fruit ripened from the red to faded-red color stages, and reached its maximum when the fruit began to soften. A close correlation was also observed between PG activity and the quality grade of dates. Top quality dates possessed activity 30 to 40% higher than lower quality grades. In addition, PG activity and the progression of softening within a single fruit were closely related to each other. Softening of a date commences at the apical end and progresses toward the stem end. The slightly softened apical half had PG activity 20 times higher than that of the firm stem half. These results strongly suggest that PG activity is involved in controlling softening of dates.

RPA 901 - ALLEVIATE SOIL, WATER, AND AIR POLLUTION

Technology--Process and Product Development

Simplifying disposal of food processing wastes. Reclamation of olive storage brines is under study on a pilot scale in a project carried out by the National Cannery Association with WU scientists serving as consultants. The project is sponsored by the olive industry and the Federal Water Pollution Control Administration. Olives have been stored since harvest in salt brine reclaimed by passage through an activated carbon column. Although only half the normal storage period has passed, the olives are in satisfactory condition at present. Carbon treatment of used olive brine appears to be suitable for at least one reuse of the brine. The treatment does not, however, remove a substantial amount of organic material from the brine. Further tests will be needed to determine how many times the brine can be reused. Meanwhile, dialysis and reverse osmosis are being investigated for removal of organics from the brine; present indications are that 75-80% removal is feasible.

Publications - USDA and Cooperative Program

RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

Chemical Composition and Physical Properties

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- COGGINS, C. W., Jr. Histological and chemical differences between soft and firm Deglet Noor date fruits. Abstract, Annual Meeting, Amer. Soc. of Plant Physiologists, Amherst, Mass. (Aug. 20-23, 1968).

Total other publications this period: 4

Flavor

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- TERANISHI, R. and MON, T. R. The use of gas chromatography in aroma research, in "Gas Chromatography," edited by Kroman-Bender. Grune & Stratton, Inc., New York (1968).
- TERANISHI, R., THOMAS, A. F. (Firmenich, Geneva), SCHUDEL, P. (Givaudan, Zurich), and BUCHI (MIT, Cambridge). The nomenclature of the sinensals. Chem. Comm. (1968) 928.

Total other publications this period: 2

Technology--Process and Product Development

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- BEVENUE, A., OGATA, J. N., HARAMOTO, F. H., and BREKKE, J. E. Effects of processing on levels of Morestan residues occurring in papaya purees. J. Ag. and Food Chem., Vol. 16, No. 5 (1968) 863-866.
- BREKKE, J. E. Tropical fruit syrups. Station Circular No. 70, Hawaii Agr. Exp. Sta. (Nov. 1968).
- RESNIK, D. Device for sorting fruit. U.S. Patent Application Ser. No. 775,166.
- RESNIK, D. System for hydrating dates. U.S. Patent Application Ser. No. 778,165.

DECIDUOUS FRUIT AND TREE NUT UTILIZATION

USDA and Cooperative Program

Problem Area		Scientist Man-Years		
		F.Y. 1969 (Estimated)		
No.	Title and Activity	Intra-mural	Extra-mural	Total
403	New and improved fruit and vegetable products			
	Chemical composition and physical properties	6.3		6.3
	Flavor	6.8		6.8
	Technology--process and product development	8.3		8.3
	Subtotal	21.4		21.4
601	Expansion of foreign markets for U.S. farm products			
	Technology--process and product development	4.8		4.8
	Subtotal	4.8		4.8
702	Protect food supplies from harmful microorganisms and naturally occurring toxins			
	Microbiology and toxicology	1.7		1.7
	Technology--process and product development		0.1	0.1
	Subtotal	1.7	0.1	1.8
	TOTAL	27.9	0.1	28.0

Domestic program supplemented by P.L. 480 funds in 4 countries totaling 52,900 U.S. dollars equivalent (Switzerland, Austria, Israel, India).

Problems and Objectives

Fruits and nuts are valued for their unique flavor, color, and mineral and vitamin content. At harvest time, markets are glutted and growers often do not get an adequate return. Processing makes these commodities available all year and opens new markets for producers, but the unique qualities of these crops are not easily preserved by processing. New and improved products for domestic and foreign markets are needed. The control of microbial contaminants in products and the reduction of water pollution by reducing processing wastes are also critical problems for the processing industry.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Developing dried fruit and tree nut products acceptable to foreign markets.
2. Controlling microbial contaminants of fruit and nut products.
3. Evaluating processing characteristics of Pacific Northwest berries and fruits.
4. Improving stability and flavor of non-frozen fruit juice concentrates and purees.
5. Evaluating changes in fruit pigments during processing.
6. Improving piece-form and powdered dehydrated fruit products.
7. Improving processes for wines.
8. Developing novel methods for controlling plant enzymes in processing and maturation of fruits.
9. Reducing processing wastes from peeling of fruits to minimize pollution.
10. Determining changes in pesticide residues during processing.

Progress - USDA and Cooperative Programs

RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

Chemical Composition and Physical Properties

Controlling plant enzymes. The preparation of insoluble but active enzymes by their reaction with glutaraldehyde has been extended to include the proteolytic enzyme, chymotrypsin, and its inactive precursor, chymotrypsinogen. The latter was activatable by the same procedure used for the

soluble precursor. The optimal reaction conditions for preparation of the insoluble but active enzymes differed for each enzyme. Insoluble but active enzymes have large potential practical application. Direct incorporation of hydroxyproline into plant proteins was demonstrated but it is probably not the principal cause of hydroxyproline inhibition of auxin-induced growth as claimed by others.

Further details of the processes whereby plants synthesize the multitude of their steroids were investigated. It was found that cholesterol, the most abundant sterol in animals, is one of the chief starting materials for the synthesis of the steroid hormones that occur in both plants and animals. Sitosterol, the most abundant sterol in plants, is also used for the production of hormones, such as progesterone and molting hormones, by plants. This is the only known function of cholesterol and sitosterol in plants. Intermediates in the conversion of cholesterol to sapogenins and molting hormones have been characterized. A cholesterol metabolite involved in the sexual reproduction of the phytopathogenic fungus Pythium periplocum has been isolated but not yet characterized.

Anthocyanin and carotenoid pigments. The reactions involved in the oxidative (peroxides) and reductive (metal-acid) irreversible decoloration of anthocyanidin pigments have been further clarified by the isolation, crystallization, and structural identification of the colorless products. The structure of a novel, natural pigment, aurantinidin, has been elucidated and synthetic work on the possible biogenetic origin of flavanoid and neoflavanoid pigments was initiated. The observed yellow to red color of fruit juices and wines is influenced by the presence of trace metals. In this connection the ability of natural phenolic flavones to form intensely yellow aluminum chelates has been investigated and correlated with their structures. The effect of light on the color reactions of flavylum salts has been studied.

Clarification of apple juice. The Colorado State University in Fort Collins has concluded research on apple juice turbidity. The formation of sediment in apple juice was demonstrated to be complex, but amenable to practical control methods. Proanthocyanidins present in apple are oxidized by enzymatic processes in milling. These oxidized products then react slowly with metallic ions and apple protein to yield a polymeric aggregate, the sediment. It was found that if oxidation of the proanthocyanidins could be prevented, sediment would not form, or its rate of formation and the amount formed would be greatly reduced. Analyses during storage studies showed a decrease in phenolic proanthocyanidin and a corresponding increase in sediment bearing these phenols. A novel dimeric proanthocyanidin has been isolated and a chemical structure proposed for this intermediate in sediment formation. An improved process was developed for preparing apple juice and tested successfully in a commercial processing line. The key step for control of oxidation is to mill under reducing conditions, using small amounts of ascorbic acid to reduce initially oxidized proanthocyanidin and a small concentration of salt to inhibit phenolase activity. By pressing the milled

fruit immediately and using minimal amounts of tannin adsorbent in filtering the juice, a product resulted with excellent flavor, light color and very little or no sediment formation on storage.

Flavor

Processed fruit flavor. Sixty-six components of Gravenstein apple essence were identified. Proportions of important esters, ethyl butyrate and ethyl 2-methylbutyrate, were higher, butyl acetate and 2-methylbutyl acetate were lower than in Delicious essence. These varieties and Golden Delicious, Winesap, Pippin, and McIntosh were compared by vapor analysis of fresh slices. Products also were analyzed by the same method.

Enzymes in apple aroma. Supported by P.L. 480 funds, the Federal Research Station for Agriculture, Switzerland, is conducting research to determine the role of enzymes in the formation of apple aroma. Effect of enzymic clarification on flavor was studied with fresh juice of Jonathan and Golden Delicious apples, and with American pectolytic enzymes. Gas chromatography showed no effect except increased methanol. Panel sensory analysis showed no effect on aroma, and improved flavor of Golden Delicious juice (low acid) perhaps due to galacturonic acid from pectin. Post harvest changes in volatiles of Golden Delicious were studied. Juice volatiles are found to have quite different quantitative composition from emanations of intact fruit. Changes in these two types during storage of the whole fruit are markedly different. Juice volatiles are now believed better related to metabolism of the fruit, and will be used in further studies. A total enzyme extract was prepared from apples. Preliminary experiments were made on the effect of this enzyme on apple volatiles in juice. Partial hydrolysis of the esters was the only consistent result observed. In projected experiments, enzymes will be added to specific substrates assumed to be precursors of volatile constituents.

Color, Texture, and Other Quality Factors

Tannin degradation in fruits. The Central India Research Institute, India, supported by P.L. 480 funds, is seeking biological methods for the degradation of tannins, in order to reduce astringency in fruits. Techniques for purification and stabilization of cashew apple tannin have been developed. Microbiological degradation on the purified tannin indicates that progressive microbial growth corresponds with reduction in astringency.

Technology--Process and Product Development

New fruits and berries for processing. Evaluation of 165 strawberry hybrids for processing has helped to reduce the number of seedlings under consideration as possible commercial varieties to about 20. Six of these are being propagated for further testing. Demonstration of preserving quality played a part in introduction of Hood strawberry by Oregon-USDA. Strongly pigmented strawberries have an unstable anthocyanin pigment in

addition to two pigments found in light-colored berries. Delayed harvest tests showed Northwest to be the best of the region's varieties for single picking by mechanical harvesting. Meeker raspberry was introduced and 22 hybrids of 220 evaluated are still under trial as possible varieties. Anthocyanin pigments of apricots were identified. Pigment development in post harvest ripening of prunes showed a single harvest practical for both fresh market and processing fruit when harvest labor is short. Freon-12 freezing produced better textured frozen strawberries, raspberries, cherries, and peaches than air-blast freezing.

Grape products. Blends of Thompson seedless grape with pomegranate juice were formulated and a product resembling tart red wine was obtained. The incident lowering of sugar results in a thirst-quenching beverage. Also neutral bland syrup was obtained by ion exchange and subsequent carbon treatment. Work on raisin jelly was initiated. Concept of osmosis driven reverse osmosis process was worked out for concentrating juices.

Inhibition of darkening was found in some wines and definite improvement in all wines when dried mycelium or alcohol extract of Botrytis cinerea (aerated submerged culture) was added to finished wines or to must prior to fermentation. Activity was followed by chemical techniques and products were evaluated organoleptically. Proper substrate is critical for good results. Addition of B. cinerea to Thompson seedless grapes results in wines with some character. Fermentation to very high alcohol with resulting unusual type of beverage is possible. Ion exchange techniques were proposed to produce stable wines without chemical contamination or change in character. The same techniques are significant for pollution control. Two new inexpensive and easy to operate filters were devised for economic filtration of lees or intractable fruit juices. Methods were developed for removal of sulfur dioxide without removal of volatiles from wine, and for removal of aldehyde by anion exchanger complex formation. Analyses of Grenache must and wine showed loss of aldehydes and hexanol with formation of lower alcohols and acetals during fermentation. Forty-three compounds were identified in grape juice and 29 in wine.

RPA 601 - EXPANSION OF FOREIGN MARKETS FOR U.S. FARM PRODUCTS

Technology--Process and Product Development

Dried fruit and dried fruit products. Engineering studies on prunes dried under conditions simulating through-flow continuous conveyor dryers show that such dryers cannot compete economically with conventional tunnel dryers for completely drying prunes. A combination of the two types of dryers may be economically feasible and superior to conventional tunnels alone. Prunes, grapes, and other waxy-skinned fruits were dipped in ethyl oleate and similar compounds. Drying rates increased 50-100%, with lesser effect at higher temperatures. Dehydrofrozen apples were prepared without SO₂ with inactivation of browning enzymes and no loss of solids. Samples of osmotic air-dried apples and peaches were prepared in diced form for evaluation in instant oatmeal.

RPA 702 - PROTECT FOOD SUPPLIES FROM HARMFUL MICROORGANISMS AND NATURALLY OCCURRING TOXINS

Microbiology and Toxicology

Health aspects of fruit and nut processing. B. cinerea mycelium is commonly found on grapes and is responsible for the flavor alteration of the high quality "noble rot" wines. When fed for 90 days at levels up to 5% of the diet, it caused no pathological or other noticeable changes in rats. Byssoschlamys fulva contamination in grape juice can be controlled by heat, filtration, or antimicrobial compounds. Byssoschlamic acid has been produced, purified, and analyzed in quantities large enough for toxicity studies. Dried fruits were found to have low microbial counts. The microbial contamination on almonds can be related to composition, harvesting, and handling practices.

Radiation sterilization of mold contaminants. Supported by P.L. 480 funds, the Institute of Biology and Agriculture, Austria, is conducting research to discover methods of increasing irradiation sensitivity of heat-resistant molds to reduce the heat requirement for fruit juice pasteurization. Heat activation of the spores of Byssoschlamys fulva before irradiation is important for radiosensitization. Ascospores germinated well when activated at 75° C. Conidiospores showed little resistance against heat. Irradiated ascospores had an LD₉₀ value of 35 Krad. Low molecular weight materials in the cells protect enzyme systems against irradiation. There is no synergistic effect of combined treatment with boric acid and irradiation of B. fulva. Experiments with single cell cultures have not been reproducible to date.

Technology--Process and Product Development

Changes in pesticide residues during processing. Contract research concerned with the chemical changes in pesticide residues during processing of fruits and vegetables has been initiated at the National Cannery Association, Washington, D. C.

Publications - USDA and Cooperative Program

RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

Chemical Composition and Physical Properties

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- SAUER, H., BENNETT, R. D., and HEFTMANN, E. Biosynthesis of Strophanthus cardenolides from progesterone. Phytochem. Vol. 7 (1968) 1543-6.
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Technology--Process and Product Development

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RPA 601 - EXPANSION OF FOREIGN MARKETS FOR U.S. FARM PRODUCTS

Technology--Process and Product Development

- LAZAR, M. E. and HART, M. R. Densified instant applesauce. Food Technol., Vol. 22 (1968) 1241.
- CORSE, J. and PATTERSON, D. C. 3-O-Sinapolyquinic acid. Phytochemistry, Vol. 8 (1969) 203-205.

RPA 702 - PROTECT FOOD SUPPLIES FROM HARMFUL MICROORGANISMS
AND NATURALLY OCCURRING TOXINS

Microbiology and Toxicology

KING, A. D., Jr., FIELDS, R. K., and BOYLE, F. P. Dried fruits have low microbial counts. Food Eng., Vol. 40, No. 12 (1968) 82.

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POTATO UTILIZATION

USDA and Cooperative Program

		: Scientist Man-Years		
Problem Area		: F.Y. 1969 (Estimated)		
No.	Title and Activity	Intra- mural	Extra- mural	Total
403	New and improved fruit and vegetable products	:	:	:
	Chemical composition and physical properties	:	0.6	0.6
	Technology--process and product development	5.1	:	5.1
	Subtotal	5.1	0.6	5.7
901	Alleviate soil, water and air pollution	:	:	:
	Technology--process and product development	0.6	:	0.6
	Subtotal	0.6	:	0.6
	TOTAL	5.7	0.6	6.3

Domestic program supplemented by P.L. 480 funds in 1 country totaling 8,200 U.S. dollars equivalent (Sweden).

Problems and Objectives

An historic decline in per capita potato consumption has been reversed by growth of markets for processed products. Consumption has been stabilized at about 110 lbs. since the early 1950's through market growth for processed potatoes. To hold these markets, new and improved products and products and processes of lower cost must continue to flow from research.

Establishment of large manufacturing plants for potato products has concentrated potato waste which now must be treated to prevent pollution of streams, rivers and lakes. Processes of manufacture must be changed to reduce pollution from potato processing.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Improving color, flavor, and stability of processed potatoes.
2. Controlling pollution and converting waste products.

Progress - USDA and Cooperative Programs

RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

Chemical Composition and Physical Properties

Lipid synthesis. "Aging" of potato discs causes increased metabolism, including heightened polyunsaturated fatty acid synthesis. The only enzyme in the reaction chains from acetic acid to fatty acid which increases in aged potato is the first acetothio kinase, which forms acetyl-CoA from acetate and CoA. This enzyme is present in two forms (isoenzymes). The second enzyme in the chain, which in vivo converts acetyl-CoA to malonyl-CoA, could not do so when extracted from tissue but the half reactions comprising this step could be demonstrated. A new fatty acid synthetase from fresh potatoes is unique in that it requires acetyl-CoA and synthesizes C₁₀-C₁₈ fatty acids. Investigation of the origin of the polyunsaturated character of fatty acids of aged potato tissue has started. Stearyl-CoA is not converted to oleyl-CoA. In germinating and maturing seeds the enzymes catalyzing the beta-oxidation of fatty acids are mostly present in subcellular organelles known as cytosomes. The site of light-induced lipid synthesis in barley leaves is the chloroplast stroma. Acetate is converted into palmitic and oleic acids. This research is conducted under a grant to the University of California at Davis.

Role of metals in vegetable enzyme action. Supported by P.L. 480 funds, the University of Goteburg, Sweden is investigating three types of metal-containing enzymes representing different roles of metals. In the first type, represented by 3-phosphoglycerate (PGA) kinase, the metal ion combines with one of the substrates, ATP. The resulting complex combines with

enzyme at a site other than that at which the other substrate (PGA) combines. Carbonic anhydrase and alkaline phosphatase were studied as representative of the second type, non-oxidase metalloenzymes. Amino acid sequence determinations of several carbonic anhydrases reveal that greatest similarities are found for kinetically similar isoenzymes from different species. Histidine, hitherto indirectly implicated in the catalytic activity, is located close to the zinc-containing active site of this enzyme. The two zinc atoms of alkaline phosphatase, bound at two independent identical sites, influence process of association of constituent subunits of this enzyme. The third type, metallo-oxidases, are represented by laccase and tyrosinase. Laccase contains two paramagnetic cupric ions (one of which is responsible for enzyme's blue color) and two diamagnetic copper atoms. Four high potential electron acceptor sites were found which undergo rapid reoxidation by molecular oxygen only when several sites have accepted electrons. A method has been developed for dissociation of cuprous ion from Neurospora. Reassociation with cupric ion is accompanied by initial reduction of this ion followed by a slow reactivation step.

Technology--Process and Product Development

Potato product quality. Determination of phenolase activity, using catechol or tyrosine as the substrate, indicates that a chemical approach to selection of tubers for resistance to blackspot may be possible. A theory for contribution of peroxidase and catalase to blackspot susceptibility was tested and demonstrated. A new peroxidase enzyme capable of oxidizing chlorogenic acid, but not catechol, was found and the kinetics of its reactions are being studied. Evidence for blackspot being an arrested state of blackheart suggests the environment in which potatoes are grown or stored is a possible cause of susceptibility to blackening. To project plans for new products and for product improvement, a wide spectrum of enzymes and chemical constituents of different varieties of potatoes is being studied. Radiant heat treatment prior to par-frying was shown to produce a French fry that stays crisp and rigid for hours in a warming oven after frying. Oil content was reduced by 20-25%.

RPA 901 - ALLEVIATE SOIL, WATER, AND AIR POLLUTION

Technology--Process and Product Development

Reducing wastes from peeling potatoes

A "dry" caustic process for peeling potatoes has been developed through the pilot plant stage. Washed, wet, unpreheated potatoes are immersed in hot, dilute lye for about 1 minute and held at room temperature for 5 minutes to allow the lye to penetrate. The potatoes are irradiated for 2 minutes under infrared burners to concentrate the lye on the potato surfaces for further reaction. The skin and softened tissue are then removed from the potatoes by rotating rolls covered with flexible fingers. Thus more than 95% of the total peel waste is removed before the potatoes are finally washed to remove

traces of lye and a small amount of softened tissue. The amount of peel removed can be adjusted as desired by changing lye concentration and immersion time. The peel is removed as a semisolid containing about 25% total solids. The waste can be burned, buried for land disposal, or fermented and mixed with other solid wastes for cattle feed. In any case, the waste and substantially all of the lye are kept out of the processing plant effluent and receiving waters. The same peeling method shows promise for beets and sweet potatoes.

Publications - USDA and Cooperative Program

RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

Chemical Composition and Physical Properties

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Technology--Process and Product Development

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- REEVE, R. M. Further histological comparisons of blackspot, physiological internal necrosis, blackheart and hollow heart in potatoes. Amer. Potato J., Vol. 45 (1968) 391-401.
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- HAUTALA, E. and WEAVER, M. L. Construction of a simplified inexpensive linear temperature programmer for gas chromatography using a capacitance-operated relay. J. Chem. Ed., Vol. 46 (1969) 122.
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VEGETABLE UTILIZATION

USDA and Cooperative Program

Problem Area		Scientist Man-Years F.Y. 1969 (Estimated)		
No.	Title and Activity	Intra- mural	Extra- mural	Total
403	New and improved fruit and vegetable products			
	Microbiology and toxicology	5.2	0.3	5.5
	Technology--process and product development	9.4		9.4
	Subtotal	14.6	0.3	14.9
601	Expansion of foreign markets for U.S. farm products			
	Chemical composition and physical properties	3.9		3.9
	Technology--process and product development	2.1		2.1
	Subtotal	6.0		6.0
702	Protect food supplies from harmful microorganisms and naturally occurring toxins			
	Microbiology and toxicology	0.4	0.5	0.9
	Subtotal	0.4	0.5	0.9
901	Alleviate soil, water and air pollution			
	Technology--process and product development	4.0		4.0
	Subtotal	4.0		4.0
	TOTAL	25.0	0.8	25.8

Domestic program supplemented by P.L. 480 funds in 1 country totaling 30,900 U.S. dollars equivalent (Poland).

Problems and Objectives

Vegetable crops are perishable and seasonal and thus subject to disadvantageous supply and price fluctuations. New products and processed products of improved quality, stability, convenience, nutritive value, safety and cost are needed to sustain domestic and build foreign markets. Processing operations must be changed to cope with the effects of mechanical harvesting and field handling of raw materials. Increased use of agricultural chemicals may require processing changes to mitigate effects of residues. Wastes from processing operations must be handled at reduced costs to prevent polluting soils and bodies of water.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Improving quality and stability of dehydrated vegetables for export.
2. Insuring removal of harmful agricultural residues in processing.
3. Protecting canned low-acid foods and other vegetable products from spoilage bacteria and from microbial contaminants.
4. Improving and developing new and improved foods by evaluating processing characteristics of new varietal selections; devising processes to create convenient, non-flatulent products from dry beans and peas; controlling the consistency of tomato products; and devising better methods for preserving the textural characteristics of frozen vegetables.
5. Alleviating soil and water pollution from vegetable processing wastes.

Progress - USDA and Cooperative Programs

RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

Chemical Composition and Physical Properties

Components of hops. Ultraviolet irradiation of lupulone, a major constituent of hop resins, has been shown to yield 4-desoxyhumulone, a precursor of humulone, the compound responsible for the bittering of beer. Attempts are being made to oxidize 4-desoxyhumulone to humulone in good yield. Also a method for the analysis of hop resins by gas-liquid chromatography has been developed. This method has been applied to beer extracts and the isohumulones present can thus be detected. This investigation of hop components provides basic information currently needed to develop new products for use in brewing.

Microbiology and Toxicology

Sporulation of food spoilage bacteria. A high frequency of sporangia formation has been achieved with Clostridium thermosaccharolyticum by restricting growth while providing a minimal essential concentration of substrate. Well matured heat-resistant spores have not yet been obtained. Metabolic changes accompany the shift from vegetative growth to sporangia formation. Ethanol accumulates, whereas in vegetative cultures acetate and butyrate predominate. A high lipid content associated with spores would require an elevated level of an NADPH-generating system. Catabolic repression of this system could inhibit sporulation.

Heat resistance, dormancy, and germination of spores. The effect of cation load on heat stability has been determined for dry spores and for spores at the optimal water activity--about 0.3. At all activities hydrogen spores are more sensitive than calcium spores in about the same degree. The load also affects dormancy of spores of Bacillus stearothermophilus and B. macerans. A method for cleaning spores of B. macerans has been developed. Phenylacetamide in low concentration germinates these spores. Calcium 4H-pyran-2,6-dicarboxylate trihydrate is crystallographically isomorphous with calcium dipicolinate trihydrate. This analog is uniquely efficient in substituting for the natural spore component in inducing germination of spores of B. megaterium and in allowing sporulation of a dipicolinate-nonsynthesizing mutant.

Technology--Process and Product Development

New vegetable varieties for processing. Liquid nitrogen (LNF) and Freon freezing (FF) of beans, snow peas, corn, cole crops, asparagus, carrots and Swiss chard showed better texture than conventional freezing in all but chard. Chard leaves became brittle and shattered. FF vegetables did not shatter as LNF vegetables did when overexposed to the freezant even though FF is but one order of magnitude slower than LNF. Vegetables with lengthwise fibrous structure split if contact with freezant was prolonged. Splits tended to close during cooking. Frozen shelled beans were made from bush beans too mature for use as frozen green beans. A pea viner was used for shelling the beans. The product was good except for tough skins. Use of water softener in blanch water helped this problem. Varietal studies of 33 new Brussels sprouts showed 3 varieties and 3 hybrids to equal or better Jade Cross in production and/or processing quality. Treatment of Brussels sprouts with Alar, a growth retardant, altered the blanch requirements for freezing and produced firmer sprouts.

Improved dry bean products. New and improved procedures have been elaborated for the preparation of several types of quick-cooking products from dry beans. Studies have been conducted to determine the nutritional value, cooking characteristics and acceptability of these products. The cooked products had a protein quality equivalent to 60% of the milk protein, casein. Uncooked standard and quick-cooking products had no nutritional value. A

low cost Lima bean product, designed for the School Lunch Program, was evaluated by a trained panel from the Human Nutrition Division. The cooking time (10 min.) was only about one-sixth of that required to prepare Limas in the normal manner and one-third the time required to cook bicarbonate-treated beans. The quick-cooking beans were also rated superior in respect to texture, and acceptable in respect to color, flavor and appearance but slightly lower than untreated beans. Hydrovac processed frozen Limas which require less than 10 min. to cook without presoaking are being commercially tested and will be market tested in the near future.

Research on bean digestibility and flatulence is being conducted under a cooperative agreement with the California Agricultural Experiment Station. Recent results confirm that oligosaccharides can account for only part of the flatus activity of beans.

Changes in cookability develop during storage of high moisture content beans. Recent studies have failed to demonstrate related changes in bean pectins.

By acidification of raw legume seeds to below pH 3.85, lipoxidase-induced off flavors can be prevented during the grinding of raw seeds for preparation of bean "milks" or slurries.

Processed tomato products. Acidification of tomato tissue during the maceration and heating phase improves juice consistency through inhibition of pectic enzyme activity and by increasing the extraction of colloidal materials. If the enzyme activity can be eliminated by heat alone without degradation of the pectic substances, the same extraction effect on consistency can be obtained by acidification of the macerate after heating but before pulping. Tomato macerates, juices and serums with pH's of 1.47 to 6.96 were held at 160° to 212° F. to determine the changes in juice consistency and serum viscosity effected over 30 minutes. Holding macerates generally resulted in a juice consistency maximum during the period. Consistency losses in juices held at 160° were 1/3 those at 212° F. Losses were most rapid at pH 6 or above. Serum viscosity losses tended to parallel the juice consistency changes.

Texture of frozen vegetables. Corn-on-the-cob was microwave blanched (M), water blanched (W), steam blanched (S), or treated by combinations of (W) followed by (M). Sensory panel results on samples stored at -20°, 0° and 20° F. indicated 4 min. (M) and 12 min. (S) samples were better than those blanched more or less severely. The better samples retained some peroxidase activity. Brussels sprouts retained some peroxidase activity after 1 to 6 min. (M). Combinations of (M) with (S) or (W) effectively inactivated peroxidase to yield products as flavor-stable at -20°, 0° and 20° F. as conventionally blanched sprouts and with as good or better chlorophyll and ascorbic acid retention. Rapid freezing did not improve the texture of frozen French fried potatoes. Apparently the extensive cell separation which is a component of the desirable mealy texture is not enhanced by rapid freezing.

RPA 601 - EXPANSION OF FOREIGN MARKETS FOR U.S. FARM PRODUCTS

Chemical Composition and Physical Properties

Vegetable flavor components. The sulfur-containing amino acids in the onion have been investigated. The importance of S-propenyl-L-cysteine sulfoxide

as the primary enzymic substrate of the onion has been demonstrated. It has been shown that 2-methoxy-3-isobutyl pyrazine is the most significant aroma component of green bell peppers. The compound has been isolated from fresh bell peppers and has been synthesized. From the volatiles of fresh tomatoes, 31 compounds have been isolated and characterized but the main odor of fresh tomato is still obscure. The importance of dimethylsulfide as a flavor contributor to canned tomato juice has been established. The volatile flavor components of carrots and carrot root have been identified.

A preliminary survey of human specific anosmias suggested that the sense of smell may include 20-30 primary odors. Collaborative work demonstrated that stereochemical principles govern the activity of alarm pheromones for ants.

Related investigations are conducted at the Biochemical Institute, Finland, supported by P.L. 480 funds. Studies continued on separation methodology and the composition of plants of the Allium species. Six new compounds were isolated from onion. Some were synthesized by using radioactive sulfur and carbon and were used for metabolic studies. A separation method was developed which combines paper chromatography with electrophoresis and permits separation of very small amounts of substances and also of D from L sulfur-containing amino acids. Several new glutamyl peptides have been isolated from Allium species and characterized.

Nucleic acids and analogues. Supported by P.L. 480 funds The Institute of Biochemistry and Biophysics, Poland, is conducting research on the synthesis of nucleic acid analogues and an investigation of their structure, to provide basic information leading to improved food flavor, color, and texture of agricultural commodities, particularly processed vegetables. A number of 6-amino and 5-alkyl derivatives of the pyrimidine bases uracil (U), thymine (T), cytosine (C) and xanthine (X), including nucleosides, nucleotides and poly-(deoxy) nucleotides, were synthesized. Extensive studies were performed with emphasis on photochemistry, conformation, and reaction with the mutagen, hydroxylamine. Other studies include intracellular localization of rat nucleases and DNA-induced inhibition of bacterial growth. Beta-5-ethyl deoxyuridine is the first found non-mutagenic nucleic acid analog with antiviral activity. The observation that poly-X is thermally degradable leads to an understanding of the mechanism of heat inactivation of plant viruses. Synthetic copolymers of X and U are the first found which complex a potentially complementary homopolymer. Unexpectedly, polymers containing the product of the action of hydroxylamine on C do not complex with poly-A. Therefore the expression of mutation must depend on the specificity of replicating enzymes as well as on base-pairing. Ultraviolet induced thymine-like dimers could be dissociated by visible light. Studies of luminescence emission show that thymine forms two monoanions at high pH. Photodimerization appears to be the only reaction product of ultraviolet-treated 2,4-diketo-pyrimidine in the solid state. Rat tissues, of which only the pancreas has a ribonuclease which can hydrolyze 3'-nucleotides, contain a specific phosphodiesterase inhibitor protein. Excess added DNA inhibits the growth of a highly competent streptococcal transforming system. This observation may have important clinical applications.

Color, Texture, and Other Quality Factors

Effect of blanching on color. P.L. 480 funds are supporting research at the Research Institute of Vegetable Crops, Poland, on the effect of blanching conditions on the color of green vegetables. To date, studies have been limited to green beans. Special attention was paid to pH of different tissues, which ranged from 5.14 for interior pod tissues to 5.64 for seed interiors. Of 12 varieties, total chlorophyll content ranged from 23.34 to 40.66 mg/100 gm fresh wt. Chlorophyll a/b ratios ranged from 1.27 to 2.56. Sprite variety of low total chlorophyll content but high a/b ratio was used for blanching experiments. Chlorophyll content decreases with aging of green pods. Extended blanching is destructive of chlorophyll. Poor retention of chlorophyll resulted from use of microwave heating for enzyme inactivation. Total ascorbic acid losses were less from steam blanching than water blanching. Blanching resulted in a rise in tissue pH and a reduction in percent total acidity. Both effects are apparently due to extraction of organic acids.

Bean proteins. Supported by P.L. 480 funds, The University of Allahabad, India, is conducting research on the protein composition and biological activity of dry beans. Albumin and globulin fractions of 24 wild leguminous seeds of 7 different genera were isolated, purified, and their amino acid composition determined. Sulfur-containing amino acids and tryptophan are the limiting amino acids in all of them. Ten do not contain tryptophan, 3 lack methionine, and 1 does not contain either of them. Nitrogenous constituents of 9 wild leguminous seeds, of the genera Bauhinia and Cassia, were fractionated. Total nitrogen varied from 2 to 5.5% and the water-soluble nitrogenous compounds from 45 to 73% of total nitrogen. Protein efficiency ratio of protein isolated from 6 wild leguminous seeds of 4 different genera, supplemented with tryptophan and methionine, was found to range from 1.00 to 1.72 as compared to 2.67 for casein. The proteolytic activity of 3 wild legumes of the genus Bauhinia seems to increase with growth of the seedlings after germination. Phosphatase activity of 6 wild legumes of the genus Bauhinia and 1 of the genus Cassia seems also to increase with growth.

Technology--Process and Product Development

Dehydrated vegetables. Air-dried onion slices of 85 to 25% water content were freeze-dried, and air-dried slices of 20 to 5% moisture were dried by microwave heating with vacuum. Final moisture contents were below 4%. Ten-gram samples of each lot were rehydrated by adding 120 g. boiling water and draining after 2, 5, 10 or 20 min. (Mixtures were approx. 160° F. after 5 min.) All samples had acceptable texture and flavor in 2 min. Freeze-dried samples rehydrated slightly more fully but were less crisp than the air-dried and microwave-dried samples.

Tomato concentrate prepared from acidified hot break juice had slightly better drum-drying characteristics and the dehydrated solids had slightly better rehydration characteristics than control products prepared from normal pH hot break juice.

RPA 702 - PROTECT FOOD SUPPLIES FROM HARMFUL MICROORGANISMS
AND NATURALLY OCCURRING TOXINS

Microbiology and Toxicology

Control of microbes in dehydrated vegetables. In contract research at the University of Illinois, the effects of pre-dehydration treatments of sliced onion on bacteriological, chemical and physical characteristics of the dehydrated product were studied. Humid heat treatment greatly reduced total plate counts of fresh onion slices but had only slight effect on total count of partially dehydrated slices. Microwave heating of sliced onions of 15.3, 6.4 or 4.0 percent moisture content had slight effect. Effective high-temperature-short-time humid heat or microwave treatments damaged pungency and color. Dipping fresh onion slices in 160 ppm chlorine dioxide solution reduced dehydrated product counts without damage to pungency or color; 80 ppm was ineffective; 320 ppm caused discoloration. Heat and chlorine dioxide effects on total counts were additive. Preliminary results indicate drying conditions have greater effect on total counts of dehydrated potatoes than surface area differences even though the mold counts seem to be closely related to drying air contamination. Observed spore incidence on blanched and on dehydrated potatoes was very low.

Control of microbes in frozen vegetables. Line studies in 6 plants freezing peas, 4 freezing corn, 2 freezing beans, and 1 freezing squash showed 87.5 percent of samples taken with less than 50,000 per g. plate count. Areas showing greatest contamination were inspection belts, air conveyors, and freezing tunnel entrances for peas; washer, inspection belt, and air conveyors for corn; and tunnel entrance for beans. Counts over 50,000 were found in 1 corn, 1 bean, and 2 pea lines. Static material in cut corn washer was a large factor in the high count corn line. No squash samples were over 50,000 per gram. Squash produced in the same plant in 1967 had counts up to 5 million. Presumptive coliforms were found in 44 percent, confirmed coliforms in 30 percent, and E. coli in 7.5 percent of samples. Aerobacter was predominating coliform. E. coli was found mostly in samples taken from points in the line after the inspection belts. Little correlation was noted between plate count and coliform or E. coli level.

Changes in pesticide residues during processing. The National Canners Association, California, is conducting contract research on chemical changes in pesticide residues during processing of vegetables to facilitate preserving products that meet pesticide residue standards. Initial efforts have been devoted largely to perfecting analytical methods, choosing suitable processing conditions, and preparing experimental canned samples for later analyses.

RPA 901 - ALLEVIATE SOIL, WATER AND AIR POLLUTION

Technology--Process and Product Development

Decentralized tomato processing. Research on decentralized tomato pre-processing and processing operations to minimize problems of waste disposal has been initiated.

Publications - USDA and Cooperative Program

RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

Microbiology and Toxicology

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Technology--Process and Product Development

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RPA 601 - EXPANSION OF FOREIGN MARKETS FOR U.S. FARM PRODUCTS

Chemical Composition and Physical Properties

- SCHWIMMER, S. Enzymatic conversion of trans(+)-S-(1-propenyl)-L-cysteine-S-oxide to the bitter and odor bearing components of onion. Phytochem., Vol. 7 (1968) 401-414.
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Color, Texture and Other Quality Factors

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Technology--Process and Product Development

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RPA 702 - PROTECT FOOD SUPPLIES FROM HARMFUL MICROORGANISMS
AND NATURALLY OCCURRING TOXINS

Microbiology and Toxicology

WOLFORD, E. R. Sanitation of the frozen food plant. Chapter 14, Vol. 3. The Freezing Preservation of Foods. Tressler, Van Arsdell and Copley, eds., Avi Publishing Company, Westport, Conn. (1968).
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SAFFLOWER, CASTOR, AND OTHER WESTERN
OILSEEDS UTILIZATION

USDA and Cooperative Program

Problem Area		Scientist Man- F.Y. 1969 (Estimated)		
No.	Title and Activity	Intra- mural	Extra- mural	Total
406	New and improved food products from field crops Chemical composition and physical properties			
		1.8		1.8
	Subtotal	1.8		1.8
407	New and improved feed, textile and industrial products from field crops Technology--process and product development			
		10.3		10.3
	Subtotal	10.3		10.3
	TOTAL	12.1		12.1

Domestic program supplemented by P.L. 480 funds in 1 country totaling 52,700 U.S. dollars equivalent (India).

Problems and Objectives

Cash crops for diversification and rotation programs need to be increased, particularly in cotton-producing areas of the western states. Crops with potential for these programs are safflower, castor and other western oilseeds. New and improved food products, animal feedstuffs, and industrial products from these oilseeds are needed to provide markets for these crops.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Developing improved processes for food products from western oilseeds.
2. Developing industrial products from western seed oils.
3. Developing improved animal feedstuffs from safflower and other western oilseeds.
4. Developing practical methods for production of safe-to-handle deallergenized castor pomace for feed use.

Progress - USDA and Cooperative Programs

RPA 406 - NEW AND IMPROVED FOOD PRODUCTS FROM FIELD CROPS

Chemical Composition and Physical Properties

Thermal and oxidative stability of safflower oil. Under a pure oxygen atmosphere, oleic oil (from UC-1 safflower) took nearly the same time to develop rancidity as a hydrogenated cottonseed oil of considerably lower iodine value (IV). The presence of even a small amount of safflower oil or cottonseed oil in oleic oil greatly lowers the stability of the oil. Odor evaluation and gas chromatographic analysis of headspace gas samples of oleic oil (from oleic safflower) IV = 92 and hydrogenated cottonseed oil IV = 6.5 under oxygen were made periodically. Oxidative off-color occurred in oleic oil after 6 months and in hydrogenated cottonseed oil after 7 months. Low boiling compounds appeared in measurable amounts in the headspace gas from oleic oil after 7-1/2 months and in hydrogenated cottonseed oil at 8 months. Cis-7-tetradecene, an oleate-like material, was synthesized and oxidized at 180° C. The volatile oxidation products identified were butanal, pentane, pentanol, pentanal, hexanol, hexanal, heptane, heptanol and heptanal. In addition, four saturated acids (C₄ - C₇) were found.

Technology--Process and Product Development

Natural antioxidants of safflower oil. In contract research concluded at the University of Arizona, an improved method of analysis for tocopherols

was developed and applied to varieties of safflower from locations in Arizona. Freshly extracted safflower oils contained 314 to 744 ppm of total tocopherol. Alpha-tocopherol was predominant, comprising 52 to 99% of the total. Oxidative stability of crude extracted safflower oils was determined by the Olcott method. There was no correlation between oxidative induction period and tocopherol content of oils. The addition of synthetic anti-oxidant (0.1% propyl gallate) increased induction periods as much as seven-fold. High oleic safflower oil (UC-1) was the most stable oil due to its totally different fatty acid content. Relation of other factors to stability was also studied. Extraction of oil with polar solvents yielded oils with increased stability--probably due to phospholipid content. In comparing oils from seeds of the same variety grown in different locations it was found that cooler climates and higher altitude resulted in oils with longer induction periods. All oils tested were less stable in water emulsions than in bulk.

RPA 407 - NEW AND IMPROVED FEED, TEXTILE AND INDUSTRIAL PRODUCTS FROM FIELD CROPS

Technology--Process and Product Development

Polymerization of monomers from oilseeds. In contract research at the University of Arizona, monomeric derivatives from selected seed oils and naval stores were polymerized and copolymerized with common monomers. These derivatives included chlorinated fatty acid derivatives and vinyl esters, acrylates and methacrylates of resin-derived acids and alcohols, as well as products derived from castor oil. Condensation polymerization, free radical polymerization and cationic polymerization of the resin-derived monomers led to clear products which in some cases had acceptable film-forming properties. Three castor-based products gave adhesive polymers, cross-linked films and internally plasticized vinyl chloride formulations respectively. The last development, internal plasticization of vinyl chloride can have widespread application in vinyl plastic food containers.

Fatty acid derivatives of castor oil. Various methods for preparing methyl 12-ketostearate from castor oil were investigated. From methyl ricinoleate, methyl 12-ketostearate 70% yield was obtained with 50% Raney nickel; from methyl 12-hydroxy stearate, 95% conversion with 5% Raney nickel; from methyl 12-hydroxy stearate, quantitative conversion with 1% copper chromate. Methyl 12-ketostearate is valuable as chemical intermediate. It was converted in high yield to 12-ketostearamide, an attractive slip agent and quantitatively to 12-amino stearic acid, a monomer and surface active agent. A process was developed for converting hydroxy stearamides to acryloxy stearamides, useful as monomers. Isomerization of methyl 12-keto-cis-9-octa decenoate to methyl 12-keto trans, 10-octadecenoate, was studied.

Urethane polymers from castor oil. Elastomers prepared from toluene diisocyanate plus combinations of castor oil-based and polyether-based polyols have been evaluated. These are soft elastomers with very low compression

sets. The resilience can be increased from very low values to intermediate values by increasing the amount and molecular weight of the polyether in the elastomer. These elastomers may be extended 70 to 350% before breaking. Tear strengths and tensile strengths are relatively low. A procedure was developed for the preparation of high molecular weight diol diricinoleates from which improved elastomers may be obtained. These were prepared in 80-86% yield by heating ricinoleic acid with dihaloalkanes and triethylamine. Dibromides react much faster than dichlorides.

Components of safflower. The color and odor components of experimental brown-stripe safflower have been removed in pilot plant experiments. These components, as well as bitter components, are present to some degree in many varieties of safflower, but the amount varies from variety to variety. Color-forming components are primarily phosphatides. Of the three major phosphatides the color forming tendency decreases in the order: phosphatidyl ethanolamine > phosphatidyl inositol > phosphatidyl choline. Recurring objectionable odors appear only in the hull oil of brown-stripe safflower which comprises 2.5-3.0% of the total oil. Bitterness in safflower meal is caused by at least five different components, all glycosidic. Large-scale separation and identification of these components is in progress.

Halogenation of castor oil. Supported by P.L. 480 funds, the Shri Ram Institute for Industrial Research, India, is conducting research on the halogenation of castor oil for use in industrial products. Castor oil, methyl ricinoleate and castor oil enriched in triricinolein were brominated at different temperatures, with and without solvent. Conditions were determined for the addition of bromine without reduction in the hydroxyl value.

Conversion of castor oil monoglycerides. Also supported by P.L. 480 funds, the Shri Ram Institute for Industrial Research, India, is conducting research to prepare and characterize triacylated monoglycerides of ricinoleic acid and evaluate them as plasticizers. The following triacyl derivatives of α -monoricinolein were prepared: acetyl, propionyl, butyryl, isobutyryl, hexanoyl, and octanoyl. Measurements of plasticizer properties of the synthetic acylated ricinoleate were made in polyvinyl chloride resins. Butyrylated monoricinolein had the best compatibility with the resin.

Polymerizable monomers from castor oil. The Regional Research Laboratory in Hyderabad, India, supported by P.L. 480 funds, is conducting research to prepare intermediates from castor oil hydroxy unsaturated fatty acids that would be useful in making polymers, protective coatings, adhesives and other products. Twelve monomers have been synthesized and submitted to Western Utilization Research and Development Division, ARS, USDA for evaluation. These monomers which contain acrylate, methacrylate, vinyl and allyl groups are all derived from castor oil. These monomers either have been or will be polymerized and the polymers evaluated. Several of these monomers have given polymers with promising film or adhesive qualities.

Improved feeds from deallergenized castor pomace. An intradermal passive cutaneous anaphylaxis guinea pig bioassay for castor allergens has been

developed which promises to be more reproducible than the previously used intravenous test. A small number of tests on sensitive human volunteers showed that previously developed deallergenization procedures are effective in producing low allergen products. Cattle feeding tests have shown that deallergized castor meals are as good as untreated meals in ruminant rations.

Feeds from safflower meal. Studies on metabolizable energy (M.E.) of safflower meal by conventional methods produced extremely erratic results. Further work indicated that the M.E. values may be a function of level fed and that an alcohol soluble component may have toxicity and interfere with the M.E. assay. Other work with rats has shown that safflower contains a laxative factor which is alcohol soluble. A new method for determination of "effective metabolizable energy" which is based on measurement of feed efficiency rather than energy balance is being developed.

Publications - USDA and Cooperative Program

RPA 407 - NEW AND IMPROVED FEED, TEXTILE AND INDUSTRIAL PRODUCTS FROM FIELD CROPS

Technology--Process and Product Development

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POULTRY UTILIZATION

USDA and Cooperative Program

		: Scientist Man-Years		
		: F.Y. 1969 (Estimated)		
Problem Area		Intra-	Extra-	
No.	Title and Activity	mural	mural	Total
410	New and improved meat, milk, and egg products			
	Chemical composition and physical properties	8.3		8.3
	Flavor	4.1		4.1
	Technology--process and product development		0.2	0.2
	Subtotal	12.4	0.2	12.6
702	Protect food supplies from harmful microorganisms and naturally occurring toxins			
	Microbiology and toxicology	2.8		2.8
	Subtotal	2.8		2.8
	TOTAL	15.2	0.2	15.4

Problems and Objectives

Increasingly efficient production of poultry, culminating in vertical integration linking breeder, hatchery, producer and processor, has been largely responsible for the increased production without increase in retail price. The continued low price to the consumer has been achieved without sacrifice in quality or safety of the product, and the per capita consumption of highly nutritious chicken and turkey meat has more than doubled in the last 20 years. However, the introduction of new forms of processing and the extension to ready-to-cook and ready-to-serve retail products requires continuing research to assure retention of quality. Of particular importance are the preservation of desirable poultry flavor, prevention of toughness, and the prevention of health hazards potentially present in such complicated operations.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Controlling Salmonella in poultry meat products.
2. Eliminating aging requirement for frozen poultry
3. Developing process modifications to improve flavor and extend variety of poultry products.

Progress - USDA and Cooperative Programs

RPA 410 - NEW AND IMPROVED MEAT, MILK AND EGG PRODUCTS

Chemical Composition and Physical Properties

Microstructure of poultry muscle. In contract research terminated at the American Foundation for Biological Research, Wisconsin, correlations between post mortem changes in ultrastructure of poultry muscle and changes in tenderness induced by electrical stimulation, beating, freeze-thawing, and heating, with emphasis on the role of muscle contraction were studied. Paired muscles were subjected to the above physical treatments immediately after slaughter, one of the pair was allowed to contract and the other was held in restraint, and comparisons were then made of relative tenderness and changes in structure. Contraction by the various treatments ranged from 5% to 60% of original length, and in all cases produced more tender muscle than occurred in the restrained controls. Observations with the electron microscope showed intense contraction of the repeating structural unit, the sarcomere, with myosin filaments pushed up against and bent at the Z line. Irregular banding, or an aggregation of striations, occurred. In restrained muscle original structural patterns were more nearly preserved. The total effect of heating involved a contraction of the fibrillar structure in some regions, a compensatory tearing and stretching of the

structure in other regions, and a coagulation transforming the myofilamentary structure into granular masses. The results provide deeper insight into the changes that must take place for tenderization of poultry muscle to be achieved.

Post mortem reactions of muscle proteins. Changes in the physico-chemical properties of the important myofibrillar protein, myosin, from red (R) and white (W) chicken muscles have been studied over the normal post mortem aging-tenderizing period. Aging decreased the phosphate splitting (ATPase) activity of myosin W, but not that of myosin R. The number of sulfhydryl groups in either myosin was not affected by aging. A new protein component, devoid of ATPase activity, developed after 24 hours aging in myosin W extractions. The extractability of actin, a myofibrillar protein, from acetone-dried, powdered chicken breast muscle has been found to increase as post mortem aging increases. The extractability of actin from similarly treated chicken leg muscle also increases from the prerigor to the rigor state, but it does not increase as aging proceeds beyond this point. Autolysis of aqueous extracts of chicken skeletal muscle is maximal at pH 3 and negligible between pH 4-7. This activity is substantially enhanced by thiols, especially in the range pH 4-6. Activation and inhibition studies suggest the concerted action of several cathepsins or proteolytic enzymes.

Flavor

Chemical nature of cooked poultry aroma. The origin of aroma in fat of cooked poultry has been investigated. The cooking of poultry is accompanied by both an aroma build-up and a sulfur build-up in the fat. To what extent, if any, this aroma and sulfur build-up in the fat are mutually interdependent has not been established. However, both the aroma build-up and the sulfur build-up come predominantly from precursors in the "lean." Thus, the ability of fat to dissolve and retain during cooking both aroma and chemical substances which originate in the lean has been established. Since this mechanism is responsible for most of the aroma that develops in fat of cooked poultry, the lean is thus a major contributor to this aroma. Aroma components which represent typical degradation products of amino acids have been identified in fat of cooked poultry. Amino acids have also been found to undergo degradation to produce volatile components when added to hot poultry fat. Thus, amino acids can give rise directly to aroma in situations such as the roasting of poultry where high local temperatures are attained.

Technology--Process and Product Development

Meat emulsion--sausage type products. In contract research conducted at the University of Nebraska, scientists found that prerigor muscle was superior to postrigor muscle in having greater emulsifying capacity, and in producing greater tensile strength and greater stability as measured by release of fat and water during cooking. Emulsifying capacity of broiler meat was not reduced by six months frozen storage (-29° C). Myofibrillar,

salt soluble (1.0 Normal Sodium Chloride) fractions of turkey muscle had greater emulsifying capacity than sarcoplasmic, water soluble (0.05 Normal Sodium Chloride) fractions. Nevertheless, the water soluble fractions made substantial contributions to the overall emulsifying capacity of the meat. Optimum chopping temperature was found to be around 13° C. Chopping times beyond 15 minutes up to 43 minutes caused appreciable decreases in stability for dark turkey muscle, but very little for white turkey muscle. Use of mechanically deboned meat required modifications in the sausage formulation, e.g., reduction in amount of fat and ice. Deboned meat samples from the Paoli machine and from the Beehive machine behaved in about the same manner.

RPA 702 - PROTECT FOOD SUPPLIES FROM HARMFUL MICROORGANISMS AND NATURALLY OCCURRING TOXINS

Microbiology and Toxicology

Factors affecting pasteurization of poultry meat. Efficacy of various agents for pasteurizing poultry was studied. Dipping in chlorine solutions was inadequate, resulting in only ten-fold bacterial reduction, and gaseous bactericides such as propylene oxide were relatively ineffective. Lactic acid, applied as a 0.5% aqueous dipping solution at 60° C., or as a 5% aqueous dipping solution at 3° C., gave 1,000-fold reductions in some cases, but the lactic acid did impart an off-flavor. An alternative surface pasteurization technique has been explored. This involves 1- to 16-minute exposure of the cool poultry surface (chicken fryer drumsticks) to hot condensing vapor from a boiling liquid of one or several components at atmospheric or modified pressures. Treated samples were evaluated for reduction in total viable bacterial count, extension of shelf life at 3° C., as measured by first detectable spoilage off-odor, and ease of removal of organoleptically detectable traces of the employed liquids from the meat. Both samples with naturally occurring bacterial flora and those inoculated with Salmonella typhimurium were used. Acetone-water and isopropyl alcohol were most effective, giving 10,000- to 100,000-fold reductions in bacterial count for 4-minute exposures, but they also were most difficult to remove in the last trace amounts. Trichlorethylene-water at 73° C. and water at 75° C. gave 100,000-fold reductions after 8-minute exposures and trichlorethylene was less of a trace-removal problem. Shelf life extensions over controls, which corresponded roughly with bacterial reductions, ranged from 20 to 40 days at 3° C. for the most effective treatments.

Publications - USDA and Cooperative Program

RPA 410 - NEW AND IMPROVED MEAT, MILK AND EGG PRODUCTS

Chemical Composition and Physical Properties

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Flavor

- PALMER, H. H. Prepared and precooked poultry products. The Freezing Preservation of Foods, Vol. 4, 163-181, Tressler, Van Arsdell, and Copley, Eds., AVI Pub. Co., Westport, Conn., Jan. 1968.

Technology--Process and Product Development

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EGG UTILIZATION

USDA and Cooperative Program

		: Scientist Man-Years		
Problem Area		: F.Y. 1969 (Estimated)		
No.	Title and Activity	Intra-	Extra-	Total
		mural	mural	
410	New and improved meat, milk, and egg products	:	:	:
	Chemical composition and physical properties	:	:	:
		4.9	0.5	5.4
	Subtotal	4.9	0.5	5.4
702	Protect food supplies from harmful microorganisms and naturally occurring toxins	:	:	:
	Microbiology and toxicology	8.7	:	8.7
	Subtotal	8.7	:	8.7
	TOTAL	13.6	0.5	14.1

Problems and Objectives

Per capita consumption of eggs has decreased about 10% in the last decade, primarily as a result of decrease in shell egg use. Egg products, eggs removed from the shell and further processed, now constitute about 10% of total production. This phase of the industry has expanded as a result of research designed to provide many high quality egg products which are more convenient to use than shell eggs. It is apparent that the development of versatile egg products could help reverse the downward trend in egg consumption. The unique functional properties for which eggs are valued in food preparation are easily damaged by processing operations such as freezing, drying, heating, and shearing. Research is needed to devise new and improved methods for production of present and new types of egg products. These methods should provide maximum kills of pathogenic microorganisms without significant destruction of the egg's functional properties.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Eliminating processing damage to egg products by developing improved processing methods and new products.
2. Controlling Salmonella in liquid and dried eggs.

Progress - USDA and Cooperative Programs

RPA 410 - NEW AND IMPROVED MEAT, MILK AND EGG PRODUCTS

Chemical Composition and Physical Properties

Egg proteins. Chemical and physical characterization of two proteins of egg white has been completed. One protein is an inhibitor of proteolytic activity; the other is destroyed upon pasteurization of egg white, and may prove useful as an indicator of pasteurization treatment. Characterization of ovomucin and studies of changes in this protein under a variety of physical and chemical conditions are continuing, as is the study of the thinning of egg white.

The ovomucin-lysozyme complex has been studied in grant research at Lincoln University, Missouri. Immunodiffusion experiments showed that an excess of lysozyme quantitatively precipitated ovomucin. The precipitated complex could be dissolved in salt solution and separated into the components by gel filtration. Thus, gel filtration can be used to determine the stoichiometry of complex formation. Acetylation of either lysozyme or ovomucin prevented complex formation, so interactions of the positively charged groups of these proteins appear to be essential to the interaction.

Freezing effects on egg yolks. Supported by P.L. 480 funds, the Indian Institute of Science, India, is conducting research to determine the physical-chemical nature of changes in egg yolk components caused by freezing and thawing. Lipoproteins in the low density portion (yolk plasma) of centrifuged yolk were confirmed to be responsible for gelation of yolk on freezing. Further studies showed that these proteins respond to gelation inhibiting and promoting agents. Removal of lipids from the plasma lipoproteins appears to allow the proteins to interact and form insoluble aggregates. The phospholipids were indicated to be responsible for maintenance of the structural integrity of these lipoproteins. That is, removal of the polar moieties of the lipoproteins by treatment with phospholipase-C appeared to disrupt the structural integrity of these proteins to such an extent that gelation would occur. Treatment of yolk with pepsin before freezing yields a fluid yolk on thawing. Although this gross observation is not new, function property tests on enzyme treated yolk indicate that reasonable possibilities exist for developing a commercial practical process that will yield thawed yolk having better handling properties.

RPA 702 - PROTECT FOOD SUPPLIES FROM HARMFUL MICROORGANISMS AND NATURALLY OCCURRING TOXINS

Chemical Composition and Physical Properties

Changes induced by pasteurization. In contract research concluded at the University of California, Davis, effects of hydrogen peroxide and of formaldehyde on egg components were investigated. At pH 9-10, peroxide changed electrophoretic patterns of purified proteins and reduced amounts of tryptophan, histidine and methionine. Changes were most noticeable in ovotransferrin and ovalbumin. At pH 4.6, peroxide destroyed more than 80% of the methionine in egg white. Reductive methylation of protein amino groups showed that loosely bound "Schiff" bases could be firmly and specifically bound without denaturation of most proteins. Eighty percent of the amino groups could be methylated, and the product properties were still similar to those of the original protein. Dilute hydrogen peroxide caused changes in yolk lipids when applied to liquid egg yolk. Changes in lipids were caused by autoxidation initiated by hydrogen peroxide. No evidence was found to indicate a health hazard in connection with hydrogen peroxide pasteurization of whites.

Microbiology and Toxicology

Heat resistance of *Salmonella*. An investigation of the effect of the chelating agents, EDTA (ethylene diamine tetra-acetate) and KENA (a mixture of polyphosphates), on the viability and heat resistance of *Salmonella* in egg white showed that supplementation of egg white at pH 8.9 with 5 mg of EDTA per ml resulted in a kill of *S. typhimurium* Tm-1 of greater than 10^6 per ml after 28 days at 2° C. At 28° C., 7 mg EDTA or 40 mg KENA per ml of egg white resulted in a similar kill in less than 24 hr. and 60 hr., respectively. When salmonellae are heated at 52.5 ° C. in egg white supplemented

with either EDTA (7 mg/ml) or KENA (10 mg/ml), their heat resistance is reduced by a factor of 2 to 6 times that in unsupplemented egg white at any given pH.

The possibility that heat killing of Salmonella may be the result of a destruction of their permeability barrier was investigated. However, several strains of Salmonella, after heat treatment for 1 min. at 50° C., were not made permeable to previously excluded compounds. But the heat treatment protected one of the strains tested (a highly heat resistant strain of S. senftenberg 775W) from two effects of EDTA, namely a change in permeability and a loss of viability, but not from a third effect, the loss of lipopolysaccharides from the cell surface. The other strains, including another of high heat resistance, were not so protected by the heat treatment.

Pasteurization of egg products. Methods for determining the minimum holding times in continuous pasteurization of egg products were developed for commercial use during normal operation without damage to the product and with almost no disturbance to regular plant procedure. Determinations showed that the residence time for the fastest particle was 0.6 to 0.8 of the average.

Pasteurization of commercially-blended salted and sugared yolks at the present specified time and temperature conditions demonstrated no important effect on product viscosity or performance. Pasteurization does not affect the large changes in these properties caused by freezing. A wide range of viscosities is obtainable in both products through application of the information obtained concerning the effects of freezing and processing variations. Acidification of salted yolks, which permits pasteurization at a lower temperature, is detrimental to product viscosity and performance and, therefore, cannot be recommended.

An egg pasteurization manual has been completed to help the egg products industry produce salmonella-free products. It describes the properties of eggs that must be preserved in pasteurization, the nature of microbiological contaminants, and accepted pasteurization methods. It also provides information on construction, installation, testing and operation of high-temperature short-time liquid egg pasteurizers.

Publications - USDA and Cooperative Program

RPA 702 - PROTECT FOOD SUPPLIES FROM HARMFUL MICROORGANISMS
AND NATURALLY OCCURRING TOXINS

Chemical Composition and Physical Properties

MEANS, G. E. and FEENEY, R. E. Reductive alkylation of amino groups in proteins. Biochemistry 7 (1968) 2192.

Microbiology and Toxicology

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